ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

EXPEDITION PROGRAMME PS92

# Polarstern

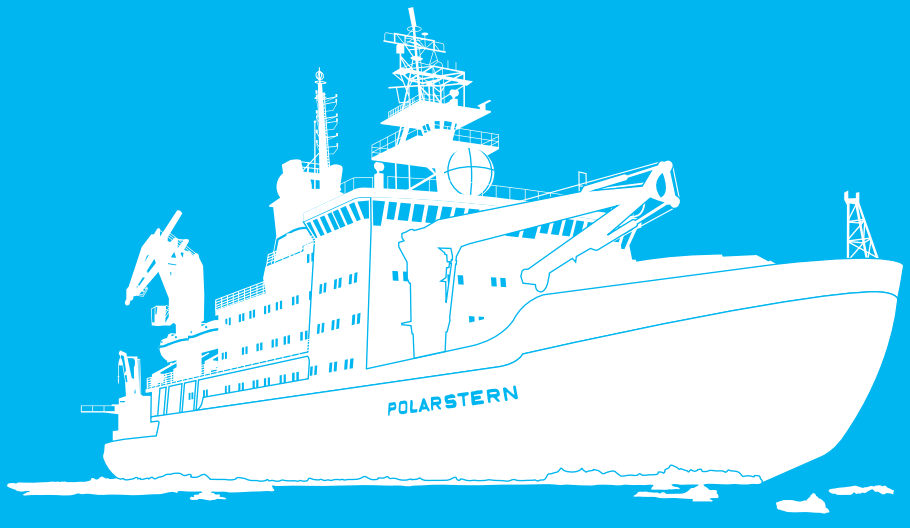
**PS92**

**Bremerhaven- Longyearbyen**

**19 May 2015 - 28 June 2015**

Coordinator: Rainer Knust

Chief Scientist: Ilka Peeken



# PS92

# (ARK-XXIX/1)

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*Contents*

# 1. ÜBERBLICK UND FAHRTVERLAUF

Ilka Peeken (AWI)

Die Expedition PS92 (ARK XXIX/1) "TRANSSIZ" (Transitions in the Arctic Seasonal Sea Ice Zone) verlässt Bremerhaven am 19. Mai 2015. Das Ziel der Expedition ist es, Prozessstudien zur Produktivität sowie zur Dynamik des Ökosystems und biogeochemischer Stoffkreisläufe im Frühjahr entlang zweier Schnitte vom Schelf bis in die Tiefsee am Kontinentalrand der Europäischen Arktis durchzuführen (Abb. 1). Dabei sollen Veränderungen der Meereisausdehnung im arktischen Ozean in der Vergangenheit mit der Gegenwart verknüpft werden. Die TRANSSIZ Expedition ist eine interdisziplinäre Kampagne von Wissenschaftlern des panarktischem Forschungsnetzwerkes ART (Arctic in Rapid Transition) gemeinsam mit Forschergruppen aus allen Forschungsbereichen des AWI und Wissenschaftlern des BMBF-Projektes „Transdrift“, sowie des französisch-kanadischen Projektes „Greenedge“.

Die konkreten Ziele dieser Kampagne sind:

- Studien zur cryo- pelagisch-benthischen Kopplung entlang des Barentssee-Schelfs bis in das Nansen-Becken unter Berücksichtigung der Untersuchung und Validierung von Proxys aus dem Meereis und den verschiedenen Wassermassen.
- Die Bestimmung und Quantifizierung der Umweltbedingungen (z.B. Nährstoffe, Stratifizierung) für die Produktivität entlang der Schnitte vom Schelf ins Tiefseebecken. Die gewonnenen Daten sollen dazu beitragen, die potenzielle jährliche Primärproduktion in einem zukünftigen eisfreien arktischen Ozean vorherzusagen.
- Untersuchungen der Wechselwirkungen der Ökosystemfunktionen und Stoffkreisläufe während des Überganges vom Frühjahr zum Sommer
- Untersuchungen der Veränderungen in der Produktivität, des Meereises und der Ozean-Zirkulation während des letzten Glacialzyklus

Nach Auslaufen von Bremerhaven auf dem Weg in das Untersuchungsgebiet nördlich von Spitzbergen wird eine detaillierte Oberflächenkartierung verschiedener Spuren- und Treibhausgase und unterschiedlicher physikalischer und biologischer Parameter durchgeführt. *In situ*-Untersuchungen von Kohlenstoffmonoxid (CO) und flüchtigen organischen Substanzen (engl. Volatile Organic Compounds, VOCs) und ihrer Mischungsverhältnisse in der Luft erlauben es, die Übersättigung des Oberflächenwassers in den unterschiedlichen Regionen in Beziehung zu der Atmosphäre zu setzen. Hydrographische Vertikalprofile sollen während der Anfahrt im gesamten eisfreien Gebiet mit Hilfe eines geschleppten (U) -CTD Systems gewonnen werden, welches auf dem Achterdeck installiert wird. Weitere Beprobungen werden dazu genutzt, die Verteilung von toxischen Algen und anderen Protisten vom Nordatlantik bis in die arktischen Gewässer zu untersuchen. Während dieser Expedition kommt erstmalig der automatisierte Probensammler AUTOFIM, der im Rahmen des EU-Projektes EnviGuard entwickelt wurde, zum Einsatz. Er nimmt Proben zur Untersuchung der Biodiversität von Protistengemeinschaften. Weitere Studien zur pelagischen Gemeinschaftsanalyse werden mit einem sogenannten Imaging Flow Cytobot durchgeführt, der kontinuierlich die Hauptgruppen der taxonomischen Zusammensetzung des Planktons analysiert.

Sobald der Eisrand nördlich von Spitzbergen erreicht ist, wird eine Teststation auf dem Meereis durchgeführt. Die zwei Hauptuntersuchungsschnitte während PS92 (ARK XXIX/1)

sind entlang der 30°O und 20°O Meridiane geplant. Die genaue Lage der Transekte und Stationen wird erst nach sorgfältiger Auswertung der tatsächlichen Meereisbedingungen während der Kampagne festgelegt. Proben aus dem Meereis, der Wassersäule sowie biologische Proben werden in einer Kombination aus Schnitten und Meereisstationen gewonnen. Es geht darum, umfassende Prozessstudien durchzuführen, die Ratenmessungen von Produktivität, und Wechselbeziehungen zwischen Ökosystemen und den Kreisläufen von Kohlenstoff- und Stickstoff beinhalten. Durch den Vergleich der Daten vom Schelf über die Schelfkante bis in die arktischen Tiefseebecken werden wir den Kohlenstoffexport von pelagischen und Meereisgemeinschaften bestimmen sowie Produktivitätsregime vergleichen, um mögliche Eigenschaften der Kohlenstoff-Produktion und -Export nach Ähnlichkeiten und Unterschieden entlang von topographie- und wassermassenbezogenen Gradienten zu identifizieren. Wenn es die Zeit erlaubt, wird ein weiterer Schnitt über das Yermak Plateau (YP) durchgeführt werden, um weitere Informationen über die Eigenschaften des arktischen Randstroms zu erhalten.

Die Meereisarbeiten beinhalteten Untersuchungen physikalischer und biogeochemischer Eigenschaften von Meereis und Untereiswasser. Während der zehn geplanten Eisstationen wird ein Standard-Set von Meereis-Kernen für biologische, physikalische und chemische Variablen sowie für die Validierung geologischer Proxys genommen. Des Weiteren werden detaillierte Studien zu Spuren- und Treibhausgasen, der Biodiversität, sowie primärer und bakterieller Produktion und zum Stickstoffkreislauf durchgeführt. Kurzzeitverankerungen werden unter dem Eis eingesetzt, um den vertikalen Kohlenstofffluss zu bestimmen. Eine kabelgesteuerte Unterwasserdrohne (engl. „Remotely Operated Vehicle“, ROV) wird unter dem Eis eingesetzt, um spektrale Strahlungsmessungen durchzuführen. Zusätzlich werden weitere Umweltparameter (z.B. Eisdicke, Salzgehalt, Temperatur) gemessen. Eine Video-Kamera am ROV zeichnet die Untereistopographie auf. Die unter dem Eis lebenden Tiere und andere Umweltparameter werden mit Hilfe eines Untereis-Schleppnetzes (engl. Surface and Under-Ice Trawl, SUIT) an verschiedenen Stationen bei und zwischen den Eisstationen beprobt. Ergänzend zu den Arbeiten auf den Meereisstationen wird mit Hilfe eines EM-Birds die Meereisdicke entlang der Fahrtroute bestimmt. Diese Eisdickenmessungen sind eine Fortsetzung und Ergänzung weiterer Flugkampagnen zur Bestimmung der Meereisdicke, wie die Erhebungen NETCARE im März / April 2015 und MELTEX / TIFAX im Juli / August 2015. Während der Eisstationen werden parallel Proben aus dem Pelagial, dem Benthal sowie für die geologische Probennahme gewonnen.

Das hydrographische Programm beinhaltet den Einsatz der CTD-Rosette, die u.a. mit einem ISUS-V3 Nitrat-Sensor ausgestattet wird, um die Nitratkonzentration *in-situ* zu messen. Zusätzlich wird ein Lowered Acoustic Doppler Current Profiler System (LADCP) an der Rosette angebracht, um die Strömungen während der CTD Profile von der Wasseroberfläche bis zum Meeresboden zu messen. Um detaillierte Vertikalprofile der Partikelverteilung, Größe und Zusammensetzung zu erhalten sowie um Zooplankton zu bestimmen, wird ein Unterwasser Video Profiler System (UVP) an die CTD-Rosette angeschlossen. Eine MSS90L Mikrostruktursonde wird die kleinstskalige Verteilung der Temperatur- und Geschwindigkeitsgradienten aufzeichnen. Dies ermöglicht die Abschätzung von Turbulenz und Durchmischung, sowie von vertikalen Flüssen von Wärme und Nährstoffen. Einweg CTD Sensoren (XCTDs) und das mobile SBE 16 CTD System des AWIs werden auf Helikopterflügen ausgebracht. Die hydrographischen Beobachtungen werden in Zusammenarbeit mit der fortlaufenden Norwegischen Jungeis-Kampagne (N-ICE2015) sowie mit dem 30°O Verankerungsarray zur Untersuchung der langzeitigen Variabilität und Entwicklung in der Atlantik Wasser Einstrom Region (A-TWAIN) durchgeführt.

Mit Hilfe der Wasserschöpfer der CTD werden Proben für die chemischen und biologischen Analysen sowie für verschiedene geologische Proxys genommen. An den Wasserproben wird die vertikale Verteilung von organischen Spurengasen und gelösten anorganischen

Verbindungen (engl. Dissolved Inorganic Compounds, DIC) in der Wassersäule bestimmt. Profile von Gelbstoffen (engl. Coloured Dissolved Organic Matter, CDOM), löslichen organischen Substanzen (engl. Dissolved Organic Compounds, DOC) und Spektralaufnahmen werden verwendet, um die Eindringtiefe der UV-Strahlung in den unterschiedlichen Meeresgebieten zu bestimmen. Um zu beurteilen, ob $TEX_{86}$ als Proxy für die Oberflächentemperatur des arktischen Ozeans benutzt werden kann, werden Proben von suspendierten Partikeln genommen. Mit Hilfe von stabilen Sauerstoffisotopenanalysen ($\delta^{18}O$) und stabilen Kohlenstoffisotopen des gesamten gelösten organischen Kohlenstoffs ($\delta\ ^{13}C_{DIC}$) werden verschiedene Wassermassen sowie der Süßwasser-Eintrag in den arktischen Ozean bestimmt. Durch die Quantifizierung der Menge und der Zusammensetzung suspendierter Teilchen (engl. „Suspended Particulate Matter"s, SPM) und deren Vergleich mit Meereiseigenschaften und Oberflächensedimentproben, werden laterale Einträge identifiziert. Hiermit kann langfristig bestimmt werden, inwieweit laterale Einträge die Rekonstruktion der Eisverhältnisse in der Vergangenheit beeinflussen. Radioaktive Neodym-Isotopenverhältnisse von Meerwasser dienen dazu, gegenwärtige und vergangene Zirkulationsmuster zu erkennen, sowie den Eintrag von hydrothermalen Quellen und kontinentaler Verwitterungsprozesse zu untersuchen.

Um das pelagische Ökosystem im Vergleich zu den Meereisgemeinschaften zu charakterisieren, werden verschiedene Parameter aus der Wassersäule erhoben. Es werden Ratenmessungen zur Primär- und bakteriellen Produktion, sowie für die Stickstoff-Fixierung durchgeführt. Ein Großwasserschöpfer (30L Go-Flo) wird für Beprobung des Protozooplanktons und kleiner Zooplanktonorganismen eingesetzt. Die Mesozooplanktongemeinschaft wird mit einem WP2-Netz und Multi-Netzen durchgeführt. Aus diesen Netzen werden auch Organismen für experimentelle Untersuchungen gewonnen. Für Studien an der Makrozooplankton- und Nektongemeinschaft wird ein mehrfach schließendes pelagisches Schleppnetz (engl. Multiple-closing Rectangular Midwater Trawl, MRMT) eingesetzt.

Um zu untersuchen, wie sich Funktionen und Gemeinschaften von Benthos Organismen in Abhängigkeit von Umweltbedingungen und der Nahrungszufuhr im Frühjahr verändern, werden die Tiere mit Hilfe von Kastengreifer und Van-Veen-Greifer gesammelt. Sedimentproben werden weiterhin für Experimente und für biogeochemische Analysen einschließlich der Bestimmung von Meereis- und Palaeoproxies verwendet. Um ungestörte Oberflächensedimente zu beproben werden Multicorer eingesetzt.

Die geologischen Kernpositionen werden sorgfältig anhand von detaillierten Kartierungen und Unterbodenprofilsystemen ausgewählt. Bathymetrische Messungen geben hochauflösende Meeresboden Karten und Informationen zur Sedimentbeschaffenheit entlang der Fahrtroute und von den Kernpositionen. Die Daten werden analysiert, um geomorphologische Informationen vom nördlichen Barentssee Kontinentalrand zur Verfügung zu stellen. Sie werden insbesondere dazu beitragen zu verstehen, welche sedimentologischen Prozesse im Untersuchungsbereich vorliegen. Für das geologische Programm dienen frühere, gut untersuchte Kerne vom eurasischen Schelf als Ankerpunkte, um weitere Kerne entlang des Tiefenprofils zu nehmen und um zusätzliche Proben des Meeresbodens für Multi-Proxy-Rekonstruktionen zu gewinnen. Die Probenahme erfolgt mit Kasten- bzw. Schwerelot. Das gesammelte Material wird es ermöglichen, laterale Veränderungen der Oberflächenbedingungen zu verstehen und erlaubt vertikale Veränderungen der Wassermassen sowie ihrer Eigenschaften zu untersuchen.

Insgesamt stellt die TRANSSIZ Expedition PS92 eine einzigartige Chance dar, früh in der Saison Prozesse des eisbedeckten, zentralen Arktischen Ozeans zu studieren und frühere Spätsommer-Studien des AWI in der zentralen Arktis wie TransArc (2011), IceArc (2012), sowie die noch bevorstehende TransArc II Expedition (Aug. – Okt.) zu ergänzen. Die Expedition wird am 28. Juni in Longyearbyen enden.

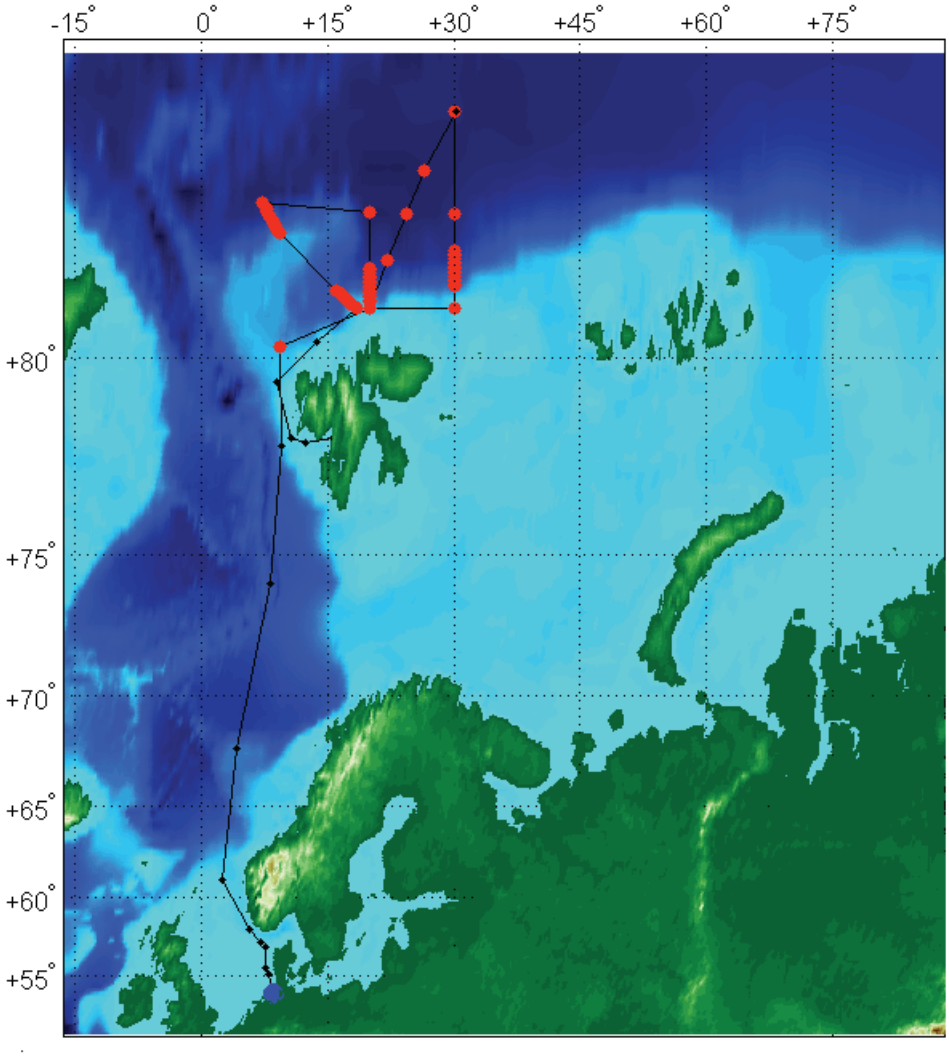


*Abb. 1: Geplante Fahrtroute und Schnitte der Polarstern Expedition PS92 (ARK XXIX/1)*

*Fig. 1: Planned cruise track and transects during the Polarstern Expedition PS92 (ARK XXIX/1)*

# SUMMARY AND ITINERARY

The expedition PS92 (ARK XXIX/1) “TRANSSIZ” (Transitions in the Arctic Seasonal Sea Ice Zone) will leave Bremerhaven on 19th of May 2015 to conduct ecological and biogeochemical early spring process studies along two shelf-to-basin transects of the European Arctic margin, linking past and present sea ice transitions in the Arctic Ocean (Fig. 1). The TRANSSIZ expedition is an interdisciplinary field campaign of scientists from the ART (Arctic in Rapid Transition) pan Arctic research network in collaboration with research groups of all AWI research divisions together with scientists from the BMBF-project Transdrift, as well as from the French-Canadian project GreenEdge.

The aims of this field campaign are to:

- Investigate the cryo-pelagic -benthic coupling from the Barents shelf to the Nansen Basin and develop, validate and compare proxies of sea ice and water masses.
- Quantify the environmental preconditions (e.g. nutrients, stratification) for productivity along shelf-to-basin transects to improve predictions of the potential annual primary production in a future ice-free Arctic ocean.
- Study the transition of spring to summer in ecosystem functioning and biogeochemical cycles
- Investigate transitions in productivity, sea ice and ocean circulation across the last glacial cycle

After leaving Bremerhaven on the way to the investigation area north of Svalbard, various trace and greenhouse gases will be studied as a function of latitude and physical and biological parameters. *In-situ* monitoring of CO and volatile organic compounds’ (VOCs) mixing ratios in the air will be performed in order to characterize the air masses and determine the super saturation of the surface seawater with respect to the atmosphere. During this transect it is planned to get vertical profiles of hydrographic measurements by using an underway (U)-CTD system operated from the back of the ship in ice-free waters. Underway sampling will be further performed to study the spatial distribution of toxic algae and their background protist communities in the North Atlantic and the Arctic Waters. For the first time, biodiversity sampling will also be carried out with the automated sampler AUTOFIM, developed in the FP7 EU-project EnviGuard. The surface ocean community composition during the cruise will be further studied by an Imaging Flow Cytobot, which is designed to record and analyse the taxonomic composition of major phytoplankton groups.

After a first test station in the sea ice, the core sampling during PS92 (ARK XXIX/1) will be carried out along the 30°E and the 20°E meridians. The exact locations of transects and sampling stations will be determined after carefully evaluating the actual sea ice conditions during the campaign. Sea ice, water column and biological sampling will be carried out in a combination of transects and individual sea ice stations. The work will include process studies for rate measurements of productivity, ecosystem interactions and carbon- and nitrogen cycling. By comparing data from the shelf, across the shelf-break and into the Arctic Ocean, we will compare the carbon export related to the plankton and sea ice communities to identify potential characteristics in the carbon production, fate and export, and to identify similarities and differences in ecosystem functioning along topography- , sea ice- and water

mass-related gradients. If time permits, the main process studies along the two shelf-to-basin transects will be complemented by a transect across the Yermak Plateau (YP) to get further information on the properties of the Arctic Boundary Current.

During the planned ten long sea ice stations, a standard set of sea-ice cores for biological, physical and chemical variables as well as for geological proxy validation will be taken. Sea ice work further involves the study of sea ice properties and under-ice water and will cover the study of trace and greenhouse gases, biodiversity, primary and bacterial production as well as a detailed study of the nitrogen cycle. Short-term moorings will be deployed under the ice to establish the vertical carbon flux. A Remotely Operated Vehicle (ROV) will be operated under the ice to focus on spectral radiation measurements, but also record environmental parameters (e.g. ice thickness, salinity, temperature) and video imaging of the under-ice environment. The under-ice fauna and other environmental parameters will be further investigated by the "Surface Under Ice Trawl" (SUIT) at a number of sampling locations, near and between the sea ice stations. Sea ice station work will be accompanied by helicopter flights to determine the large-scale distribution of sea-ice thickness with an EM-bird along the cruise track. These ice thickness surveys are a continuation of the large-scale airborne sea ice thickness surveys in March/April 2015 (NETCARE) and July/August 2015 (MELTEX/TIFAX).

During the sea ice stations, parallel sampling of pelagic and benthic ecosystems and geological cores will be conducted. The hydrographic program involves regular CTD casts also equipped with an ISUS-V3 nitrate sensor to monitor *in-situ* nitrate concentrations and a Lowered Acoustic Doppler Current Profiler system (LADCP) for recording current velocity and direction during the CTD casts. A UVP (Underwater Video Profiler System) will be attached to the rosette to provide detailed vertical profiles of particle distribution, size composition and the zooplankton community. Fine-scale temperature and shear, needed to infer turbulence, mixing, and heat or nutrient fluxes, will be measured with a MSS90L microstructure profiler. Expandable CTD sensors (XCTD) and the AWI's mobile SBE 16 CTD system will be deployed with helicopters. The hydrographic studies are performed in collaboration with the ongoing Norwegian Young sea ICE cruise (N-ICE2015) as well as the 30°E mooring array of long-term variability and trends in the Atlantic Water Inflow region (A-TWAIN).

During the entire expedition, water samples will be taken from the water bottles of the CTD rosette to study the chemistry, biology and various geological proxies. This will allow monitoring the vertical distribution of organic trace gases and dissolved inorganic carbon (DIC) in the water column. The profiles of Colored Dissolved Organic Matter (CDOM), and Dissolved Organic Carbon (DOC) together with light spectra from hyper-spectral radiometers will be used to establish the penetration depth of ultraviolet radiation into the different types of oceanic waters. To evaluate if TEX86 can be used as a proxy for Arctic sea-surface temperature, this tracer will be collected from suspended particles. Stable oxygen isotope analysis ($\delta^{18}O$) and stable carbon isotopes of the total dissolved inorganic carbon ($\delta\ ^{13}C_{DIC}$) will provide an assessment of water mass signatures and freshwater composition within the Arctic Ocean. By quantifying the abundance and composition of Suspended Particulate Matter (SPM) and comparing these to sea ice and surface sediment samples, the significance of large-scale lateral transport, and how this may affect the reconstruction of ice conditions in the geologic past, will be studied. Radiogenic neodymium isotope ratios of seawater will be used to investigate present and past ocean circulation patterns, hydrothermal inputs and continental weathering regimes.

The water sampling will also cover a basic set of variables to monitor the pelagic ecosystem in comparison to the sea ice biota. This will include rate measurements for primary and bacterial production and nitrogen fixation. A large-volume profile (30L Go-Flo) will be taken for estimates of the protozooplankton and microzooplankton composition. Quantitative sampling of mesozooplankton will be carried out by using WP2 nets and multinets.

Organisms for experimental studies will be taken from these net hauls. For macrozooplankton and nekton, a Multiple-closing Rectangular Midwater Trawl (MRMT) will be used. The distribution of makrozooplankton and pelagic fish will be monitored continuously on selected transects with *Polarstern's* EK60 echosounder.

To investigate how benthic community structure and function will change as a function of environmental conditions and food input during the spring bloom, benthic communities will be collected using box corers and Van Veen grabs. The material will further be used for experimental and biogeochemical analysis of the benthic surface sediment layers, including sea ice- and paleo-proxies. Multi-corers will be used to get undisturbed core tops of near-surface sediments.

The geological core positions on our transects will be selected using detailed bathymetric mapping and sub-bottom profiling systems. Bathymetric surveys using Hydrosweep and other sensors will give high-resolution seabed maps and sub-bottom information along parts of the cruise track and from the target research sites. The data will be analysed to provide geomorphological information for the seabed at the northern Barents Sea continental margin and will help understanding the sedimentological processes in the research area. For the geological programme, existing well-studied cores from the Eurasian Margin will be used as anchor points to get additional seafloor samples for multi-proxy reconstructions, and to complete depth transects using giant box cores, and gravity/Kastenlot cores. The collected material will allow investigating lateral changes in surface conditions and vertical changes in water masses/properties.

Overall, the TRANSSIZ expedition PS92 presents a unique chance to study early-season processes in the ice-covered Central Arctic Ocean and complements earlier late-summer studies of the AWI conducted in the Central Arctic, e.g. TransArc (2011), IceArc (2012), as well as the upcoming TransArc II expedition in fall 2015. The cruise will end on 28th June 2015 in Longyearbyen.

# 2. SEA ICE PHYSICS

T. Krumpen (AWI), S. Willmes (UTR), P. Cochrane (AWI), C. Katlein (AWI),
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**Objectives**

Climate models agree that the sea ice extent and thickness will further decline through the 21st century in response to atmospheric greenhouse gas loading (Zhang et al. 2006, Massonnet et al. 2012). Furthermore, ice drift and deformation increase and net ice growth rates decrease (Spreen et al. 2011, Rampal et al. 2009). To determine associated changes in the Arctic sea ice volume requires consideration of changes in ice volume fluxes that appear at the major gates of the Arctic, such as the Fram Strait and along the pathways feeding the exit gates. Given the importance of the Fram Strait sea ice fluxes for the Arctic sea ice volume changes, aim of the sea ice physics group is to measure ice thickness of sea ice in the southern Transpolar Drift. The ice thickness surveys complement earlier measurements made by moorings, drifters and from ships. It is a continuation of the large scale airborne sea ice surveys in March/April 2015 (NETCARE) and July/August 2015 (MELTEX/TIFAX). A second objective of the sea ice physics group is to quantify the horizontal and vertical distribution of short-wave radiation in sea ice and the uppermost ocean. The interaction of sunlight and sea ice is of critical importance for the energy- and mass-balance of the ice-covered Arctic Ocean. The energy penetrating into and through sea

ice is the major energy source. Therefore, it is crucial for the eco-systems and geochemical processes in and beneath the sea ice. This work continues studies from the expedition ARK-XXVI/3 (TransArc, 2011).

### Work at sea

*AEM ice thickness measurements*

We will use airborne electromagnetic (AEM) induction sounding to measure sea ice thickness by helicopter surveys. The method utilizes the difference of electrical conductivity between sea ice and sea water to estimate the thickness of sea ice including the snow layer if present. During ice station, ice thickness will be determined at floe-scale using a ground-based EM instrument pulled on a sledge across the ice. These measurements will be complemented by snow thickness measurements.

*Optical measurements*

During ice stations, under-ice irradiance and radiance measurements will be made along horizontal and vertical transects with a remotely operated vehicle (ROV). In addition, surface measurements of solar irradiance are performed with Ramses spectral radiometers above the sea ice during ice stations.

*Routine sea ice observations*

Hourly sea ice observations will be carried out by trained observers on an hourly basis from the bridge of *Polarstern* according to the ASSIST protocol (Arctic Shipborne Sea Ice Standardization Tool). The observations will be made during normal working hours between 7 am and 9 pm.

### Data management

The sea ice thickness, sea ice observations from bridge, remote sensing to support ice navigation data and optical data will be released following final processing after the cruise in the PANGAEA data repository and other international databases.

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# 3. PHYSICAL OCEANOGRAPHY

M. Janout (AWI), A. Nikolopoulos (ABWR), J. Hölemann (AWI), B. Juhls (GEOMAR), M. Korhonen (FMI/UH), A. Randelhoff (UiT)

**Background and objectives**

The physical oceanography component of this interdisciplinary TRANSSIZ-cruise aims to map the physical properties (temperature, salinity, currents, and turbulence) of the study region during the little-studied early summer period. Information will be gained on the properties and pathways of the Atlantic water inflow, on shelf-to-basin fluxes, and on the vertical mixing of energy and matter under the sea ice in a key region of the Arctic Ocean (AO).

The Atlantic water (AW) inflow is the dominant feature in the Atlantic sector of the AO. The inflow follows two prominent pathways, the Barents Sea branch and the Fram Strait branch. The Barents Sea branch is characterized by saline and warm waters that are cooled along the propagation across the Barents Sea shelf, before it enters the AO through St. Anna Trough in the northern Kara Sea. The Fram Strait branch follows the continental slope north and then eastward after passing by Svalbard. The complex topography in Fram Strait forces a bifurcation of the inflow around 80°N, where one part propagates eastward, and another part follows the topography around the sickle-shaped Yermak Plateau (YP). The partitioning of the two Fram Strait branches, and the associated spatial and temporal variability, are yet to be deciphered. Before reaching 30°E, both portions are reunited and follow the continental slope eastward as a well-defined Boundary Current (BC), which distributes AW heat and nutrients across the AO. Fig. 3.1 provides an example of the warm temperature distribution in the boundary current.

Except for its impact on the pathway of inflowing AW, the YP has been highlighted as a region featuring energetic physical processes related to topographically-trapped and intensified tidal currents. YP may therefore be a potential biological hotspot due to enhanced vertical mixing of AW heat and nutrients.

In most AO regions, the warm Atlantic (or Pacific) derived waters are separated from the ice-covered surface by a pronounced halocline layer (i.e. a layer of strong stratification due to vertical salinity differences). The halocline is maintained by either river runoff (Western Arctic) or by fresh surface water due to seasonal ice melts (Nansen Basin), and is a crucial feature to protect the sea ice from warm ocean water. However, near the inflow region north of Svalbard, Atlantic water is still found near the surface (see Fig. 3.1), and thus contributes to seasonal ice melt as well as delays in the fall freeze-up relative to other regions.

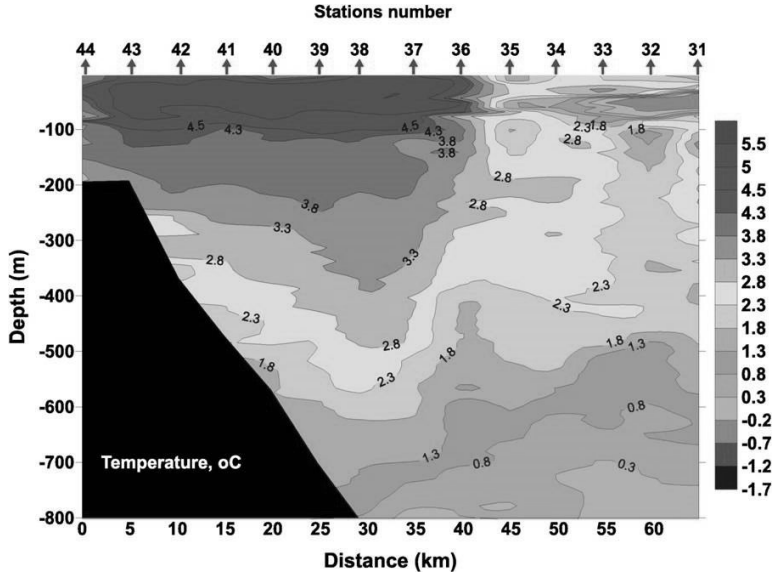


*Fig. 3.1: Temperature section across slope north of Svalbard (~22°E) from September 2013 showing the AW inflow with near-surface temperatures >5° C. Acknowledgement: A-TWAIN project, PI Vladimir Pavlov/NPI.*

The AO currently progresses toward a seasonally ice-free ocean, with several record-low ice extents within the last decade. The seasonal ice retreat occurs in the season of maximum biological productivity, and is hence of special interest for biology, oceanography and sea ice dynamics. The mechanisms responsible for these changes are not yet fully understood. Furthermore, despite the obvious potential importance, the contribution of warm subsurface waters to the ice reduction is even less understood, and hence requires further efforts to measure oceanic heat fluxes, in particular during the transition seasons when sea ice melts and forms.

The oceanographic objectives include collecting detailed information on the properties of the Arctic Boundary Current in several cross-continental slope transects north of Svalbard and on YP, as well as to measure currents, turbulence and vertical exchange under the sea ice.

**Work at sea**

*Instrumentation*

The measurements will be undertaken with a range of instruments, from the ship as well as from the ice. Conductivity-Temperature-Depth (CTD) measurements are carried through with the ship-board SBE 9/11+ CTD system, which is combined with a SBE 32 Carousel Water Sampler (Seabird). The CTD carousel (rosette) will also be equipped with a TRDI Lowered Acoustic Doppler Current Profiler system (LADCP) for recording velocity during the CTD casts. Velocity in the upper water column (200-300 m) is additionally recorded by the vessel mounted 150 kHz ADCP (Teledyne - RDI). Supplementary to CTD measurements we will use expandable CTD sensors (XCTD) launched from the ship or helicopter, as well as AWI's helicopter-borne mobile SBE 16 CTD system (Seabird). An underway (U)-CTD system (by Ocean Science) will be operated from the back of the ship while the ship is transiting through ice-free waters. Fine-scale temperature and shear, needed to infer turbulence, mixing, and heat or nutrient fluxes, will be measured with a MSS90L microstructure profiler (Sea & Sun Technology and ISW Wassermesstechnik), which is equipped with shear- and fast response CTD sensors.

*Sampling*

Along three transects of TRANSSIZ (30°E, 20°E and YP) we plan to carry out detailed hydrographic measurements by use of the shipboard CTD rosette, which also will serve for water sampling for the biogeochemical analysis. The LADCP on the CTD rosette will concurrently record vertical velocity profiles throughout the water column. The horizontal scales of currents in high latitudes are small (~1-10 km) and, hence, for capturing typical boundary current features, a fine station resolution is required. Over the continental slope, within the BC core, we therefore plan to carry out CTD casts every 4-6 km (example Fig. 3.2). Each CTD station will be accompanied by MSS measurements either from the ship or from sea ice, in free-falling mode. In addition, current measurements of the upper ~200 m along each transect will be collected with the vessel mounted ADCP. The higher resolution PO sampling plan will be pursued above the continental slope during each passage across the expected pathway of the Arctic Boundary Current. Once the cruise passes the physically dynamic slope region, station spacing will increase. The overall amount of CTD stations will depend strongly on the sea ice situation.

During the long-term stations, CTD casts will continuously be carried through for water collection and deep CTD profiles, while the bulk of the PO work will concentrate on sea ice-based sampling. From the beginning until the end of each long-term station, we will deploy a 300 kHz RDI Workhorse ADCP under the ice, in order to collect information on currents and shear. The ice-mounted ADCP provides a fine-resolution velocity profile directly under the ice, since *Polarstern*'s vessel-mounted ADCP cannot record velocity data in the uppermost 25 m. These data will complement the MSS casts, which will be repeatedly carried out at the beginning of each hour throughout the long-term stations. These sampling methods will generate short (1-2 days) time series of currents and vertical fluxes, and hence valuable physical insights, relevant for biogeochemical processes and for the role of oceanic heat on sea ice melt.

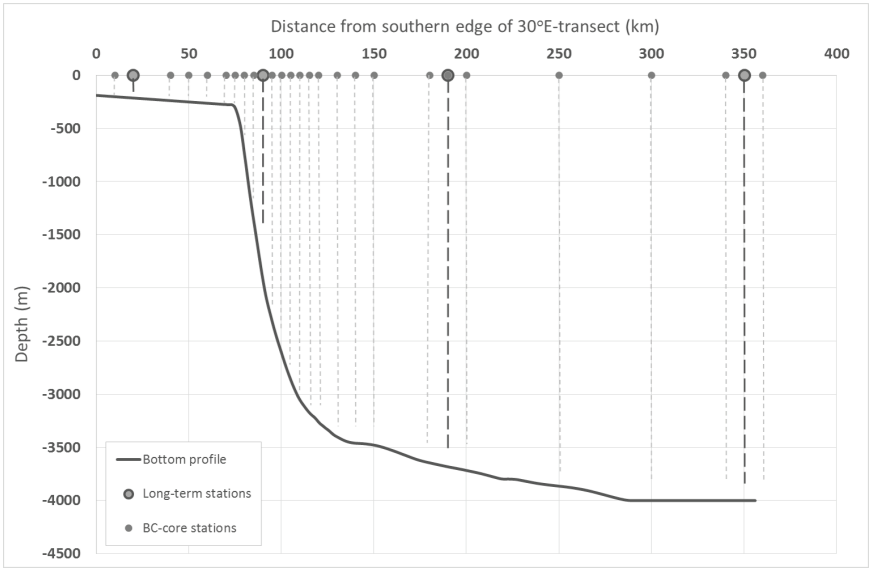


*Fig. 3.2: Side-view of the 30°E-transect (south-north) with tentative locations of the densely spaced sampling BC-core stations over the continental slope, as well as the longer-term (36-h) stations. The same type of high-resolution sampling scheme is planned for the 20°E and YP transects.*

The spatial resolution of the ship-CTD data collection may be further improved by XCTDs or by use of AWI's helicopter-borne mobile CTD system. While steaming to and from the study area, the data collection may further be supplemented by information from UCTD measurements (sampling possible in open water only).

**Expected results**

The measurements are expected to provide essential oceanographic insights, and additionally complement (or be complemented by) the biogeochemical measurements during TRANSSIZ. Furthermore, collaborations with other programmes such as the ongoing Norwegian Young sea ICE cruise (N-ICE2015) as well as the 30°E mooring array of long-term variability and trends in the Atlantic Water Inflow region (A-TWAIN) will further provide relevant information to the physical data collected during this expedition.

**Data management**

All oceanographic data (CTD, LADCP, VMADCP, microstructure) collected during TRANSSIZ (PS92) will be delivered to the PANGAEA data repository and to the appropriate national data centers after post-cruise calibration and processing.

# 4. TRACE GASES

V. Gros (LSCE), H.S. Findlay (PML), R. Sarda-Estève (LSCE), B. Bonsang (LSCE- not on board), C. Boissard (LSCE, not on board)

**State of the art and objectives**

The polar areas are very sensitive to global warming and particularly the Arctic Ocean which is dramatically subject to rapid changes in the extend of ice cover with short and long term consequences on complex feedback processes including climatic, physical, biological, and chemical aspects. These changes affect the distribution of nutrients and impact the distribution of primary producers, phytoplankton, at the base of the reservoir's total biomass. The reduction of sea ice cover and thickness through positive feedback processes lead to the extension of the free oceanic surface. As a consequence, the retreating of sea ice and the subsequent increase of light penetration in different wavelengths in the ocean surface layers, will deeply modify both photosynthesis and photochemical processes, and the production of trace gases through photosynthesis of planktonic biomass and photolytic degradation of dissolved organic matter. Such effects can result in variation of trace gases emission by phytoplankton, strongly dependent on available radiation, with subsequent impact on the atmospheric chemistry of boreal zones through the tropospheric ozone cycle and its precursors.

Results obtained during the previous arctic campaigns on board *Polarstern* (ARK-XXV and ARK-XXVI campaigns in summers 2010 and 2011) show that all the newly ice free ocean surface acts as a more intense source of volatile organic compounds (VOCs) to the atmosphere. These first studies have shown also the presence of enhanced concentrations of carbon monoxide, alkenes and isoprene at the bottom of ice cores. These facts have raised emerging questions on the role of photolytic processes and photosynthetic activity for VOCs production in sea ice and the magnitude of the turnover of the biogenic gases in the ice cover and the upper part of the ocean.

Considering that oceanic emissions processes of these different VOCs might be tightly coupled and have never been simultaneously investigated, the objective is to understand and to quantify the impact of the various physical processes sensitive to climate change on the emissions of trace gases in the Arctic areas, waters and ice pack. The focus will be placed on the gases having possible important feedbacks for the chemistry of the atmosphere and climate: dimethylsulphide, carbon monoxide, and volatile organic compounds in the group of polyunsaturated (isoprene) and oxygenated hydrocarbons. Among these species unsaturated hydrocarbons (such as isoprene) and carbon monoxide (CO) have a strong impact on the OH radical and ozone budget. Isoprene and DMS act also as a secondary source of the fine and ultra-fine fraction of the marine aerosols with a direct effect on the radiation balance. Isoprene production from the oceans results from the '*in-situ* 'biological production in the euphotic zone by seaweeds and phytoplankton under PAR radiation (Bonsang et al. 2010 and references therein). Besides isoprene, the super-saturation for a large part of the ocean of the surface seawaters is also well established for carbon monoxide (CO) and light hydrocarbons (NMHCs) (Plass et al. 1992; Stubbins et al. 2006 and references therein) which are produced by different processes involving the photo-degradation of dissolved organic matter through the influence of UV radiation and direct production by living cells under PAR (Gros et al. 2009). The magnitude of the source is dependent on the concentration at the sea surface which is itself dependent on a number of biogeochemical or physical parameters such as principally: UV and visible irradiance at the sea water surface, quantum efficiency of conversion of DOC to CO or VOCs, attenuation coefficient of UV radiation in the water layers and turbulent mixing in seawater. Very few studies are available on the quantification of emissions volatile organics by the polar areas and particularly sea ice, they mainly concern carbon monoxide (Song et al. 2011) and only some preliminary measurements for alkenes and isoprene are available (Boissard et al. 2015 in preparation). The situation is more drastic for oxygenates, since measurements in seawater have been only performed at present in tropical areas (Williams et al. 2007).

Questions that this project would like to address are:

- What is the distribution of oxygenates VOCs, isoprene, dimethylsulphide and carbon monoxide dissolved in the surface seawater as a function of latitude and different parameters including physical (i.e. sea water temperature, radiation) and biological parameters: chlorophyll, planktonic abundance, dissolved inorganic and organic carbon?
- How does the vertical distribution of the concentration of dissolved gases in seaweater reflect the different production processes? What is the role of direct emission by plankton metabolism (under PAR) versus photoproduction processes by DOC degradation (under UV)?
- What is the budget of these gases in the ice and in the water column; in particular, is it possible to establish a balance between the production rates in seawater and ice and the losses by exchanges with the atmosphere and other bio-chemical or physical losses processes (oxidation, microbial consumption)?
- How does the ice-edge bloom affect the production of trace gases and the uptake of $CO_2$ into the ocean; how does the bloom affect the carbonate system, and what are the implications for seasonality of ocean acidification; How does the carbonate system change across the ice-edge and shelf-to-basin transitions?

**Work at sea**

During this cruise, three kinds of measurements will be performed:

- Measurements in surface seawater from *in-situ* sampling when the ship is moving.
- On-board analyses of samples taken at different depths with Niskin bottles during the ship's station,
- Measurements in ice core from samples taken at the ice stations.

*In-situ* sampling will consist in surface sea water continuously analysed for its content in dissolved organic trace gases, dimethylsulfide, oxygenated VOCs (acetone, methanol, acetaldehyde, acetonitrile) isoprene and carbon monoxide. Seawater samples collected from the water pump will be continuously introduced in an equilibration system (for CO) or in a stripping chamber (for VOCs and DMS). Dissolved gases will be equilibrated or extracted with clean synthetic air, and analysed by gas chromatography (GC) and proton transfer mass spectrometer (PTR/MS for DMS and VOCs). Two instruments will be consequently used: a GC equipped with a mercuric oxide detector for CO monitoring and a PTR/MS instrument for DMS, isoprene and oxygenates. Measurements frequencies are about 1 minute for dissolved VOCs in seawater and 5 minutes for dissolved CO.

*In-situ* monitoring of CO and VOCs mixing ratio in the air will be eventually performed on board in order to characterize the air masses and determine the supersaturation of the surface seawater with respect to the atmosphere.

Measurements of the vertical distribution of organic trace gases and DIC in the water column will be performed from the samples collected on station using the CTD-Niskin rig. Water samples will be taken at each station, sampling at a number of depths through the water column to achieve a water column profile. The number of samples analysed per vertical profile as well as the frequency of the vertical profiles studied will be adapted on board depending on the parameters variability observed. A focus will be put on sampling of the euphotic zone and the chlorophyll maxima will be especially investigated.

Water samples will also be collected from ice sack holes and from ice cores at different depth. All water samples will be analysed on-board for their content in CO, VOCs, dissolved inorganic carbon (DIC) and total alkalinity (TA).

For CO, and VOCs water samples will be collected into glass bottles and immediately outgassed for the analysis of their content in dissolved gases following a procedure previously described (Tran et al. 2013; Boissard et al. in preparation, 2015). Basically, CO will be measured using gas chromatography with a hot mercuric-oxide detector (RGD2, Trace Analytical, Menlo Park, CA, USA) directly coupled to the extraction cell. The system is composed of two 1-mL nominal volume stainless-steel injection loops (for samples and calibration, respectively). The column (0.77 m length, 0.32 cm o.d., containing molecular Sieve 13X 60/80 mesh) is working at 95°C, and the mercuric-oxide detector is operated at 265 °C.

For DIC and TA water samples will be collected into borosilicate glass bottles with ground glass stoppers (50 mL). Sample bottles are rinsed and filled according to standard procedures detailed in Dickson et al. (2007). Samples were poisoned with 10 µL mercuric chloride. Duplicate samples were taken from all situations when possible. Samples will be brought into the chemical laboratory and brought to room temperature and analysed within 24 hours of collection. Ice cores will be cut down into small pieces and sealed in air-tight Tedlar bags spiked with mercuric chloride. The ice will be left to melt overnight; the resulting water will then be used for the analysis.

DIC will be measured using an automated analyser (Apollo SciTech Dissolved Inorganic Carbon Analyser, Model: AS-C3, s/n: C31202). The analyser adds a strong acid (10% H3PO4 plus 10 % NaCl solution), which causes all carbon species within the seawater to be converted to $CO_2$. The resulting $CO_2$ gas is purged from the water sample by the pure nitrogen ($N_2$) carrier gas. The $N_2$ gas flow carried the $CO_2$ from the sample through a drying system that includes a cooling system to reduce water vapour. The concentration of the dried $CO_2$ gas is then measured with the LI-7000 $CO_2$ analyser (a differential, non-dispersive, infrared gas analyser). The total amount of $CO_2$ in the sample is quantified as the integrated area under the concentration-time curve, and converted to DIC using a standard curve created from analysing known volumes of the Certified Reference Materials (Dickson Laboratory, Scripps, USA). A measurement volume of 0.75 mL is used, with up to 5 measurements made from each sample. Values outside a 0.1 % range will be excluded from the final result.

TA will be measured using the open-cell potentiometric titration method on 12 mL sample volumes using an automated titrator (Apollo SciTech Alkalinity Titrator Model AS-ALK2, s/n: A2 1002). Calibration will be made using Certified Reference Materials (Dickson Laboratory, Scripps, USA). The principal is described by Dickson et al. (2007). Replicate measurements will be made per sample.

### Preliminary (expected) results

This comprehensive data set will allow documenting horizontal and vertical distribution of trace gases in the Arctic Ocean as well as in the ice. These data will be compared with data obtained in 2010 and 2011 and differences will be evaluated by examining biological and physical parameters in order to determine the main drivers. The budget of the water column in reactive trace gases will be determined and the role of the ice will be investigated.

DIC and TA together with temperature, salinity and nutrients can be used to calculate the remaining carbonate system parameters including $pCO_2$, pH, and calcium carbonate saturation states. Combining with auxillary data on biological and physical factors, a spatial description of the carbonate system can be made to assess the different processes and their impacts on $CO_2$ uptake, carbon cycling, lysocline depth, etc. Data will feed into model developments for assessing the Arctic Ocean's ability to take up carbon, as well as the current state of the Arctic in this region with relation to ocean acidification. Data will also be useful to the paleo-oceanography group (lysocline depth and relation to foraminifera) and the biogeochemistry group.

### Data management

Trace Gas data will be made available to the public via PANGAEA after publishing. DIC and TA data will be submitted to the British Oceanographic Data Centre (BODC). The unrestricted availability from BODC will depend on the required time and effort for achievement of individual datasets and its status of scientific publication. Ultimately a DOI will be issued for the dataset and the data will be made open access.

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# 5. GEOCHEMISTRY

## 5.1 Organic biomarkers in suspended particles

E. Park (AWI), G. Mollenhauer (AWI, not on board)

### Objectives

Organic biomarkers are often used to reconstruct sea-surface temperatures. In particular, the biomarker index $TEX_{86}$ is increasingly applied in regions where other techniques do not yield reasonable estimates. However, the depth at which the precursor organisms for the glycerol dialkyl glycerol tetraether (GDGT) lipids, on which the index is based, thrive is poorly known. Efforts to calibrate the index in the Arctic have resulted in overestimation of sea surface temperature, which may be related to the special ecological conditions in this region. The goal of our study therefore is to investigate $TEX_{86}$ on (suspended) particles collected from the surface waters, from water column profiles, and from in and under the sea-ice, and compare these data with results from underlying surface sediments. The results will help address the following research questions:

- Does $TEX_{86}$ in the Arctic record sea-surface temperature?
- Is there a sub-surface maximum in GDGT concentration suggesting a sub-surface habitat of the precursor organisms?
- Do sea-ice associated communities have a distinct $TEX_{86}$ signature, which might alter the pelagic signal?

### Work at sea

During cruising and station work, surface water taken from the ship's seawater inlet will be filtered onto glass fibre filters (pore sizes 0.7 and 0.45 µm). At long-term stations, *in-situ* pumps shall be deployed to filter large volumes of water at various water depths. Sampling depths will be determined according to CTD transmissometer data, where depths with highest particle abundances will be selected. At sea-ice stations, particles contained within sea-ice cores shall be collected onto filters depending on availability.

**Preliminary (expected) results**

The results expected address the above mentioned research questions. They will help to further refine the calibration of the proxy.

**Data management**

Data to be obtained from samples collected during this cruise will be archived in PANGAEA and published in international peer-reviewed journals.

## 5.2 Watermass signatures ($\delta^{18}O$, $\delta^{13}C_{DIC}$)

S. Büttner (GEOMAR), K. Werner (BPCRC), D. Bauch (GEOMAR, not on board)

**Objectives**

The overall purpose of the stable oxygen isotope analysis ($\delta^{18}O$) and stable carbon isotopes of the total dissolved organic carbon ($\delta^{13}C_{DIC}$) is to provide an assessment of water mass signatures and freshwater composition within the Arctic Ocean and to understand the seasonal variation of these signals.

**Work at sea**

We plan to take water samples for stable oxygen isotope analysis ($\delta^{18}O$) in parallel to CTD measurements and hydrochemical sampling. Sampling of water for $\delta^{13}C_{DIC}$ will performed only at selected stations.

Sampling is planned within the halocline and the intermediate waters down to a depth of about 1,000 m. Sampling within the Deep and Bottom waters is planned for a selection of stations. Sampling will be conducted across.

*Sampling plan*

Water sampling for $\delta^{18}O$ analysis (50 ml) and $\delta^{13}C_{DIC}$ (100 ml) will be taken from CTD-rosette throughout the water column at all available rosette CTD stations and depth levels (but no multiple casts). With planned sampling depth levels at about : 10 m, 25 m, 50 m, 75 m, 100 m, 150 m, 200 m, 250 m, 300 m, 350 m, 400 m, 500 m, 600 m, 800 m, 1,000 m. At selected stations further sampling down to the sea floor at additional depth levels: 1,250 m 1,500 m 1,750 m 2,000 m, 2,250 m, 2,500 m, 3,000 m to the bottom depth.

We will take 50 ml of water for each 1 $\delta^{18}O$ sample from the CTD-Rosette. No water is needed for flushing. Since $\delta^{18}O$ is measured on the oxygen of the $H_2O$ itself, it is not a trace-element and its conservation is relatively easy. No poisoning of the water is necessary and some gas-exchange on a short time scale (e.g. bubbling while sampling) is of no harm.

For $\delta^{13}C_{DIC}$ flushing is needed and 100 ml samples have to be drawn without “bubbling”. With flushing about 200 ml are needed. Samples are poisoned with 2 ml of saturated $HgCl_2$.

**Preliminary (expected) results**

Samples for $\delta^{18}O$ and $\delta^{13}C_{DIC}$ analysis will be transported to Kiel. Analysis will be conducted at the Leibniz Laboratory at Kiel University, Kiel, Germany and at the Stable Isotope Facility at CEOAS at Oregon State University, Oregon, USA within 1 year.

Based on hydrological data and stable oxygen isotope analysis ($\delta^{18}O$) the influence of mainly shelf-derived meteoric waters and modification by sea-ice processes (melting or formation) can be quantified (Bauch et al. 1995).

From previous investigations in the Central Arctic Ocean e.g. in summer 2007 we know that there is spatial and temporal variation of freshwater distribution within the Arctic Ocean halocline on an interannual to seasonal timescale (Bauch et al. 2011). With the planned work

on PS92 we expect to learn more about the potential seasonal variation of freshwater within the different layers of the Arctic Ocean halocline.

**Data management**

Data will be stored at the Pangaea data repository and will be made public after publication at PANGAEA data repository.

## 5.3 Suspended particulate matter (SPM)

S. Büttner (GEOMAR), C. Wegner (GEOMAR, not on board)

**Objectives**

The overall goal is to study the particle flux from the Barents shelf to the Nansen Basin to improve our understanding of the pathways of suspended particulate matter (SPM), which is critical in order to draw the connection between sediment dynamics, optical properties and ecosystem dynamics under a changing climate on the one hand. Furthermore quantifying the abundance and composition of SPM, and comparing these to sea ice and surface sediment samples is required to understand the significance of large-scale lateral transport, and how this may affect the reconstruction of ice conditions in the geologic past.

**Work at sea**

To investigate shelf-to-basin particle flux process studies in the water column will be carried out. SPM concentration in the water column can be derived by direct measurements (water samples) and indirect measuring devices (transmissometer). In general, losses of light propagating through water can be attributed to two primary causes: scattering and absorption. By projecting a collimated beam of light through the water and placing a focused receiver at a known distance away, one can quantify these losses. The ratio of light gathered by the transmissometer's receiver to the amount originating at the source is known as the beam transmittance (Tr), which provides an indication of total. In order to estimate the SPM concentration from the transmissometer signal water samples from defined water depths will be taken, filtered through pre-weighed HVLP filters by MILLIPORE (0.45 microns), and washed carefully with distilled water after filtering.

**Preliminary (expected) results**

All filters will be analysed in GEOMAR, Kiel (concentration, grain size). All transmissometer measurements will be correlated with corresponding *in-situ* water samples to obtain accuracy by taking the effects of different mineralogy, varying particle darkness, and salinity of ambient water on the response of the turbidity meter into account.

The results expected address the mentioned research questions above and will improve our knowledge on shelf-to-basin particle fluxes and add to the quantification of the environmental preconditions for productivity.

**Data management**

Data will be archived in the PANGAEA data repository and will be made available in open access after publication.

## 5.4 Water mass proxies - radiogenic neodymium (Nd) isotopes of seawater

S. Büttner (GEOMAR), G. Laukert (GEOMAR, not on board)

**Objectives**

The overall objectives are to study water mass transport along a shelf-to-basin transect. Radiogenic neodymium isotope ratios of seawater have been successfully used to investigate present and past ocean circulation patterns, hydrothermal inputs and continental weathering regimes, since Nd behaves independently of any fractionation processes in the oceans (e.g. evaporation) and its residence time is on the order of or shorter than the average circulation time of the global ocean (Frank, 2002).

**Work at sea**

Water samples will be collected in 10 L acid-cleaned plastic canisters and additionally acid-cleaned 1 L plastic bottles and immediately filtered through AcroPak™ Capsules with Supor® Membrane (pore size: 0.8/0.45µm) to avoid exchange of dissolved Nd/REE and Nd/REE in the suspended particles.

**Preliminary (expected) results**

Measurements of Nd isotopes of seawater will be conducted by Multi-Collector Inductively Coupled Plasma Mass Spectrometry (MC-ICPMS) at GEOMAR Helmholtz Center for Ocean Research Kiel.

The results expected address the mentioned research questions above and will help to use the potential of the tracer information.

**Data management**

Data will be archived at the PANGAEA data repository and will be made available in open access after publication.

## 5.5 Source and transformations of chromophoric dissolved organic matter and its role in surface ocean heating

M. Zablocka (IOPAN), J. Meler (IOPAN), M. P. Kowalczuk (IOPAN, not on board),

**Objectives**

- identify individual CDOM components in the oceanic waters and ice cores in the Barents Sea and characterize them by spectral properties of excitation/emission fluorescence and absorption
- identify processes that control distribution of specific components in time and space and find those components, which distribution is controlled by physical conservative mixing of water masses with distinctly different optical and hydrological properties
- derive empirical relationships between specific CDOM components and inherent and apparent optical properties of marine waters and salinity
- derive empirical relationships between spectral properties of CDOM fluorescence and absorption with DOC concentration. Investigate the temporal and spatial variability of $a_{CDOM}$/DOC and FDOM/DOC
- establish the zonal variation of the depth integrated action spectra (the product of the CDOM absorption spectrum and spectral distribution of underwater irradiance at given depth) of the CDOM photodegradation

### Work at sea

The work at sea will include taking water samples at each station on 5- 6 depths from 100 m depth to the surface. Depths of water sampling will be decided on board during CTD cast and will depend on local biogoechemical and hydrological features such as: depth of the mixed layer, depth of the thermocline, depth of the deep chlorophyll a maximum and depth of the dissolved oxygen concentration. At each station there will be deployment of profiling radiometers – the Compact Optical Profiling System, C-OPS to measure the solar irradiance distribution in the function of depth in the UV, Visible and PAR spectral ranges.

Water sample will be processed on board of *Polarstern*. The water will be filtered through the set of filters to collect samples of suspended material for estimation of following bio-optical parameters: chlorophyll a concentrations, absorption of light by photosynthetic pigments and non-algal particles. Water samples will be also processed for estimation absorption and fluorescence by Chromophoric Dissolved Organic Matter and concentration of Dissolved Organic Carbon.

The work on ice stations will include taking cores of ice for chlorophyll a concentrations, absorption of light by photosynthetic pigments and non-algal particles, absorption and fluorescence by CDOM and concentration of DOC. At each ice station there will be deployment of profiling radiometers – C-OPS from the ice edge.

### Preliminary (expected) results

We expect to collect set of optical, bio-optical and biogeochemical data that enables us establish basin scale variability of those parameter. We also expect to recognize the basin scale variability of distribution of CDOM, and DOC concentrations. Collected the data should also enable us to establish the penetration depths of ultraviolet radiation into the different types of oceanic waters and recognize the variability in photo-degradation potential of the Dissolved Organic Matter by calculating the depth average CDOM photo-degradation action spectra.

### Data management

All data will be available after processing to cruise participants on the co-authorship agreement. Copies of processed data files will be deposited at AWI's data repository PANGAEA.

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# 6. SEA ICE BIOLOGY

## 6.1. Ecological consequences of climate change in the Transpolar Drift Region

Peeken, I. (AWI), U. Dietrich (UHB), M. Ungermann (AWI)

**Objectives**

Sea ice is of major importance in the polar oceans since it affects the solar radiation fluxes due to its reflective properties and it is a habitat and feeding ground for various organisms of the polar ecosystem. The Arctic Ocean is now in a state of rapid transition that is best exemplified by the marked reduction in age, thickness and extent of the sea ice cover, at least in summer. The European Arctic margin is largely influenced by drift ice formed on the Siberian shelves and carried to the Fram Strait via the Transpolar Drift. Sea ice thickness for the various regions of the Transpolar Drift between 1991 and 2007 showed a reduction in modal ice thickness from 2.5 m towards 0.9 m. A long-term trend towards thinner sea ice has profound implications for the timing and position of the Seasonal Ice Zone and the anticipated ice free summers in the future will have major implication for the entire ecosystem and thus alter current biogeochemical cycles in the Artic.

Due to the generally low solar elevation light is considered to be the key factor for primary production in the ice covered oceans. Light penetration in the Arctic is generally reduced by the sea ice cover and additionally snow greatly reduces light transmission through the ice. In the framework of climate warming, the atmospheric moisture budget in the Arctic is forecast to change, resulting in an increasing snow cover and thus reducing the light for primary production. However, the reduction from MYI to seasonal ice and additional increase of melt ponds on FYI will substantially increase light transmission through ice.

A systematic inventory of ice algae-biomass collected by Russian colleagues and on various *Polarstern* cruises in the 80ties until recently could show that in the 1980s the biomass concentrations of sea ice algae in the Central Arctic were in general very low. However, the massive loss of sea ice thickness in recent decades has apparently led to increasing biomass in the central Arctic e.g. during the record low 2012. Contrary to the assumption that the phytoplankton benefits from the reduction of sea ice, it was shown that sea ice algae are the biggest profiteers in the changing central Arctic (Fernández-Méndez et al. 2015). Due to the decrease of the sea ice thickness, evolving habitats for sea ice algae have been observed in surface melt ponds (Fernández-Méndez et al. 2014) and under the ice (Assmy et al. 2013). This new evolving ice aggregates in Arctic melt ponds and under the ice might have consequences for the carbon budget, leading to major implications for the cryo-benthic and cryo-pelagic coupling of the Arctic Ocean. It involves the export of large biomass much further north in the Central Arctic as was previous the case (Boetius et al. 2013). Changes in sea ice habitat structure and ice algal production will affect the trophic transfer of sea ice-derived carbon through the under-ice community into pelagic food webs, with unknown consequences for biodiversity, ecosystem functioning and resource availability.

During ARK-XXIX/1 we aim to study the following topics:

- Investigate sea ice biota on shelf to basin transects in the Transpolar drift region and compare this with historic data
- Study the biodiversity of the various ice habitats in comparison to the under ice water

- Study the optical properties of sea ice for the growth conditions of ice algae
- Reveal the role of melt pond associated communities for the ecosystem
- Improve estimates of spatial variability of sea ice algae

**Work at sea**

During the ice stations ice cores will be taken for biological, chemical and biogeochemical analyses. We will further sample the water under the ice and if present, melt pond water. The depth of the sampling under the ice will be based on the profiles of the CTD and fluorescence probe which will be conducted prior to the water sampling in collaboration with the Iceflux team. We will measure environmental parameters as sea ice temperature, snow depth, free board, ice thickness, water flow velocity below the ice, and directly on the ice floe. In collaboration with the sea ice physics & Iceflux group hyperspectral radiometer will be used to measure the spectral composition of the light under the ice for distinguishing the ice-algae biomass. Point measurements with this type of sensor will be carried out in drill holes for a direct validation of the hyperspectral estimates of ice-algae concentrations with pigment measurements from ice cores and further optical properties as particle absorption and CDOM from entire sea ice cores in collaboration with biogeochemistry group. Measurements of light will be carried out under and above the ice.

The water and ice core samples will be transported back to the ship. A regular sea ice sampling involves the collection of melted ice-core sections, under-ice water and melts pond water. In general we aim to collect the following variables: salinity, nutrients, coloured dissolved organic matter (CDOM), dissolved inorganic carbon (DIC), and filters for particulate N, P and C. Additionally, algae biomass and composition will be determined by size-fractionated chlorophyll, marker pigments, molecular markers and cell counts (microscopy and flow cytometer). Also biogenic silicate, particulate organic carbon and nitrogen (POC, PON) and the isotopic composition of POC and PON ($\delta^{13}C_{POC}$ and $\delta^{15}N_{PON}$) will be determined. Marker pigments and biogenic silicate will additional be sampled from the CTD casts in collaboration with the Norwegian flux team.

Flow cytometer measurements of the pico- and nanoplankton from all habitats including the entire water column will be directly counted on board as well as the CDOM concentrations in collaboration with other groups. All other samples will be stored and measured at the AWI for determination of all other variables.

**Preliminary (expected) results**

The aim of this study is to understand the variability and biodiversity of the sea ice-associated biomass with respect to the sea ice conditions and nutrient availability, to access the role of sea-ice biota for the cryo-pelagic, cryo-benthic coupling under different environmental scenarios from the shelf to the deep sea basin. Special emphasis will be given to understand the role of melt ponds in the carbon cycling of the Arctic Ocean. These data can be used for modelling approaches to access the role of climate change on the carbon cycle of the Arctic Ocean.

**Data management**

*Samples*

Except for the microscopic samples, all other variables taken during the cruise will be processed during or after the cruise (1 year). Leftovers of the microscopic samples and the DNA will be stored at the Polar Biological Oceanography at the AWI for approximately 10 years.

*Data*

Data from ice work will be collected during and after the cruise. The entire data set will be submitted to PANGAEA within 1-2 years. The unrestricted availability from PANGAEA will depend on the progress of a PhD thesis based on the data.

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## 6.2. Heterotrophic microbial activity and the fate of ice associated productivity

G. Meisterhans (DFO), I. Peeken (AWI), A. Niemi (DFO, not on board), C. Michel (DFO, not on board)

### Objectives

Arctic ecosystems are changing as sea ice extent, thickness and distribution patterns are altered with climate change. As the physical structure of the Arctic changes there is evidence that the foundational components of marine food-webs are shifting with potential radiative impacts throughout the ecosystem. The magnitude of ice associated productivity is expected to change and shifts in the seasonal progression from ice algae to phytoplankton can already be observed. In the central Arctic it is possible that the reduction in ice thickness could enhance the growth of ice algae and their early season support of pelagic and benthic communities. Scenarios of increased primary productivity in the Arctic Ocean have already spawned interest in the potential for new or expanded fisheries. However, it is not clear if increased primary production would support higher trophic levels or alternatively be processed and sequestered within the microbial food-web.

Within the changing Arctic, the central role of heterotrophic microbes in biogeochemical cycles needs to be understood to determine food-web efficiency and the capacity of the Arctic Ocean to sequester or release $CO_2$. The transformation, recycling and remineralisation of particulate material by bacteria, and other heterotrophic microbes, influence the magnitude and composition of sea-ice, surface water and sinking organic carbon pools. Therefore, they directly impact cryo-pelagic-benthic coupling and the signal of ice associated productivity in other species and habitats.

The main objective of this project is to investigate microbial mediated transformations of ice associated productivity in a seasonal ice region of the high Arctic. The activity of autotrophic and heterotrophic microbial communities will be assessed and the dissolved and particulate organic carbon pools will be quantified. Rates of bacterial (including archaea) production and community respiration rates will be measured. Cell abundance and the relative proportion of functional groups will be determined. Together, these measurements will allow for the

calculation of bacterial growth efficiencies and the development of organic carbon budgets. This project will also compare heterotrophic processes between different types of ice associated habitats including bottom and upper ice sections; waters near the ice-water interface and melt ponds.

**Work at sea**

Sea ice and water at the ice interface will be collected along the two shelf-to-basin transects. Opportunistic sampling of other ice habitats, e.g., melt ponds or leads, will be conducted when possible. Sample processing and production/respiration measurements will be conducted on board the *Polarstern*. Flow cytometry samples will be frozen (-80°C) and dissolved organic carbon samples will be kept refrigerated until later analyses. Basic sea ice and snow properties will be collected in collaboration with the other groups at each station.

Planned analyses and linkages to group collaborators (indicated by *) for sea ice and surface water samples include:

- Bacterial production (3H-leucine incorporation)
- Community respiration (dissolved oxygen measurements)
- Photosynthetic parameters (Pulse Amplitude Modulated fluorescence, Phyto-PAM)
- Autotrophic and heterotrophic microbial abundance (flow cytometry)
- Cell size and functional group estimate (flow cytometry)
- Dissolved organic carbon (DOC)
- Dissolved nitrogen (DN)
- Primary production (14C uptake)*
- Particulate organic carbon (POC)*
- Algal biomass (chlorophyll *a*)*

For sea ice samples, the relative importance of attached versus free living bacteria will be investigated using a 3 µm size fractionation (via filtration) for production and possibly community respiration measurements.

**Preliminary (expected) results**

It is expected that the sea ice samples will contain higher microbial biomass and activity than surface waters. The magnitude of biomass and production will depend on the stage of ice algal development during the time of sampling, i.e., pre-bloom, bloom or post-bloom. We hypothesize that heterotrophic production and activity will be a more significant component of sea-ice processes in the basin as compared to sea ice over the shelf region.

**Data management**

Integrated datasets for all measurements will be compiled and verified following the analyses of all samples. Meta-data will be available shortly after the completion of the cruise and will be posted pass word protected in PANGAEA or on the Polar Data Catalogue. Following the publication of the results, the data will be made available on PANGAEA and BIOCHEM, a national archive of biogeochemical data for Fisheries and Oceans Canada.

# 7. SEA ICE ECOLOGY, PELAGIC FOOD WEB AND COPEPOD PHYSIOLOGY- ICEFLUX / PEBCAO

H. Flores (AWI, UHH), B. Niehoff (AWI, not on board), J.A. van Franeker (IMARES, not on board), G. Castellani (AWI), F.L. Schaafsma (IMARES), H. Tonkes (AWI). M. Vortkamp (AWI), M. van Dorssen (v.D. Met.)

## Objectives

The Arctic sea ice-associated ecosystem is facing drastic changes, most evidently a significant decline of the extent and duration of sea ice coverage. This process is accompanied by ocean warming and increasing acidification. Sea ice decline will significantly affect ecosystem functioning, because sea ice ecosystems thrive significantly on carbon produced by ice-associated microalgae. Species feeding in the ice-water interface layer, such as Polar cod *Boreogadus saida*, play a key role in transferring sea ice-derived carbon into pelagic food webs, and ultimately to the birds and mammals inhabiting the Arctic (David et al. 2014). Future changes in Polar sea ice habitats will affect primary production in the water column and sea ice and the distribution patterns of ecological key species, with unknown consequences for the ecosystems (e.g. Flores et al. 2012a). To better understand potential impacts of changing sea ice habitats for Arctic ecosystems, the HGF Young Investigators Group *Iceflux* in cooperation with IMARES (*Iceflux-NL*) and AWI's PEBCAO group, aim to quantify the trophic carbon flux from sea ice into the under-ice community and to investigate physiological capacities of abundant Arctic copepods to adapt to environmental conditions. The trophic carbon flux from sea ice into the pelagic and under-ice community will be quantified by 1) quantitative sampling of the pelagic and under-ice community and environmental parameters with a Multiple-closing Rectangular Midwater Trawl (MRMT), a Surface and Under-Ice Trawl (SUIT) equipped with a sensor array and *Polarstern's* EK60 echosounder, 2) detailed investigations of bio-optical properties of sea ice habitats during sea ice stations, and 3) using molecular and isotopic biomarkers to trace sea ice-derived carbon in pelagic food webs. An experimental study will focus on the resilience of *Calanus* spp. to a changing food regime. The intended TRANSSIZ expedition PS92 presents a unique chance to study early-season processes in the ice-covered Arctic Ocean. TRANSSIZ complements an earlier late-summer study of *Iceflux* and PEBCAO in the Arctic Ocean (IceArc, ARK XXVII/3, 2012).

## Work at sea

*SUIT sampling*

The association of under-ice fauna with sea ice properties and other environmental parameters will be investigated with a Surface and Under-Ice Trawl (SUIT: van Franeker et al. 2009; Flores et al. 2012b). A sensor array mounted on SUIT will collect real-time data on sea ice and water column properties during trawling, including an under-water video camera, a CTD with built-in fluorometer, and a hyper-spectral radiometer (RAMSES, TriOS). SUIT deployments will be conducted at regular intervals along the TRANSSIZ transects. At the planned ice stations, SUIT hauls will be conducted on arrival and/or departure to obtain the maximum possible comparability of under-ice species composition and abundance and under-ice sensor data with data collected during the ice stations.

*Pelagic sampling*
We aim to also investigate deeper-dwelling key species of the pelagic food web, such as euphausiids, amphipods, and fishes. A Multiple opening Rectangular Midwater Trawl (MRMT) will be used at many SUIT locations. For biomarker analyses articulate Organic Matter (POM) will be collected from filtered seawater obtained from the CTD rosette. In addition, *Polarstern's* EK60 echosounder will be running during steaming to continuously map the distribution of fish and macrozooplankton in the water column. Mesozooplankton composition and depth distribution in relation to ice coverage will be determined by means of vertical Multi net tows (150 µm mesh size) from 1,500 m depth to the surface. In addition, Bongo net hauls (200/300 µm mesh size) will be taken to collect organisms for biochemical analyses (carbon, nitrogen, protein and lipid content, fatty acid composition), for enzyme activity analyses (citrate synthase, digestive enzymes) and for experiments.

*Sea ice work*
Our sea ice work is conducted in close collaboration with AWI sea ice physics (T. Krumpen et al.), and sea ice biology (I. Peeken et al.). On-ice work will consist of ice coring, bio-optical measurements, and collection of under-ice water samples. At each coring site, cores will be collected for biomarker analysis; in-ice and meiofauna communities. The bio-optical measurements are an important prerequisite for the calibration of hyper-spectral light profiles obtained from SUIT. They require the deployment of an L-arm under the ice with a mounted spectral radiometer to acquire the spectral light properties of the sea ice and the under-ice environment. At L-arm survey sites, ice cores will be extracted and in collaboration with the sea ice biology group processed for chlorophyll *a* content in order to determine the relationship of ice algal biomass with the under-ice spectral light properties. On coring sites, we will also take samples of under-ice water to investigate microzooplankton communities, and deploy an under-ice CTD for vertical profiles of the upper 50 m of the water column under the ice.

*Biomarker analysis*
The trophic significance of ice algae in Arctic pelagic food webs will be investigated with isotopic biomarkers. To this end, organisms caught with SUIT, MRMT and other gear will be sampled and stored at -80°C, and later submitted to biomarker analysis (stable isotopes and lipids) at the AWI. To sample the trophic baseline needed for the interpretation of biomarker results (ice algae and phytoplankton), melted sea ice cores and seawater samples will be filtered.

*Diet analysis*
To further investigate the significance of ice algae in the diet of under ice fauna and the significance of under ice fauna in the diet of top predators, stomach contents and energy content of trophic key species will be investigated at IMARES. Organisms caught with SUIT, MRMT and other gear will be sampled and stored in formalin, -80°C and -20°C and will be studied further using microscopy, DNA analysis, calorific content analysis and C/N ratio analysis.

*Biodiversity studies*
To assess the relationship between sea ice habitat properties, food web structure and biodiversity, we will sample the meio- and microfauna communities in sea ice as well as the microzooplankton composition of the ice-water interface layer.

*Experimental work*
In incubation experiments, we will study the response of dominant Arctic copepods to different algal species (*Thalassiosira weissflogii*, diatom, and *Oxhyrris marin*a, dinoflagellate).

Particularly, we will focus on grazing, respiration, egestion and egg production rates in relation to food quality, which will all be measured on-board. In addition, we will deep freeze individuals over the course of the experiment to determine changes in body mass and enzyme activities. This will elucidate to which extent the copepods are dependent on the spring diatom bloom and whether they are flexible in exploring different food resources.

**Expected Results**

We expect to obtain a comprehensive dataset of the distribution and diversity of pelagic and under-ice fauna in the Barents Sea sector of the Arctic Ocean. In conjunction with physical data from our collaborators of the sea ice physics group, our environmental datasets will help to model the relationship of ice-associated biota with their habitat. Biomarker and diet samples will be analysed in the home laboratories and will contribute to a more quantitative understanding of the role of ice algal production and sea ice-associated zooplankton in the Arctic food web. Experiments on the feeding biology of dominant mesozooplankton species will help to predict their response to a changing food regime in the pelagic realm, e.g. when phytoplankton compositions changes due to ocean warming and acidification. These datasets will be complemented by an integrated inventory of the biodiversity and community structure of sea ice infauna and protist diversity in relation to environmental properties of sea ice habitats.

**Data management**

Almost all sample processing will be carried out in the home laboratories at AWI and IMARES. This may take up to three years depending on the parameter as well as analytical methods (chemical measurements and species identifications and quantifications). As soon as the data are available they will be accessible to other cruise participants and research partners on request. Depending on the finalization of PhD theses and publications, data will be submitted to PANGAEA, and will be open for external use.

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# 8. ECOSYSTEM

## 8.1 Nutrients, primary production and nitrogen cycling (GREENEDGE)

F. Bruyant (Takuvik/UnL), M.A. Blais (Takuvik/UnL), M. Fradette (UnS), Y. Huot (UnS, not on board), M. Babin (Takuvik/UnL, not on board), J.E. Tremblay (Takuvik/UnL not on board).

### Objectives

The main objectives of the Greenedge team will be to understand how sea ice and physical oceanographic processes affect nutrient supply, the composition of algal and zooplankton assemblages, primary productivity and the assimilation of fixed inorganic nitrogen.

### Work at sea

The work at sea will involve water sampling with the rosette (shipboard) and at stations designated for ice work. Nutrient samples will be stored frozen for post-cruise analysis on an Auto-analyzer 3 (see Martin et al. 200), except for ammonium which will be determined on board using the sensitive fluorometric method (Holmes et al. 1999). In order to obtain rapid information on nutrient conditions during the expedition, an ISUS-V3 nitrate sensor will be attached to the rosette (to be post-calibrated after the expedition). A UVP (Underwater Video Profiler System) will also be attached to the rosette to provide detailed vertical profiles of zooplankton. An underway system designed to record and analyse the taxonomic composition of major phytoplankton groups (Flow-Cytobot) will be connected to the ship's water intake system. Water samples taken at the long stations will be incubated in the laboratory with $^{14}$C-labeled bicarbonate to determine the parameters of photosynthesis-irradiance (P-E) curves. New and regenerated production will be estimated by incubating samples with $^{15}$N-labelled nitrate or ammonium in deck (plexiglass incubators with running seawater) and *in-situ* (bottles attached to sediment trap moorings) depending on stations and conditions (Tremblay et al. 2006).

### Preliminary (expected) results

Our results will provide information on the current (incubations) and prior (nutrient drawdown) distribution of primary production across the survey area and contribute to the interpretation of spatial patterns in the other variables measured by our group (assemblage composition of phytoplankton and zooplankton) and others (sedimentation, benthic fluxes). The parameters of P-E will yield precious information for the regional tuning of remote-sensing algorithms to estimate primary production from space. Estimates and nitrate and ammonium assimilation will complement those of another group measuring $N_2$ fixation, providing a detailed overview of nitrogen cycling and new biological productivity in the area (i.e. the quantity of organic matter available for export to the higher food web or the deep ocean and sediments).

### Data management

Post-cruise sample analysis and data processing will be done at Laval University and University of Sherbrooke and the final results will be made available to other participants. Data processing will necessitate an input of data (e.g. physical data from the CTD, HPLC, particular absorption) from other groups before our final numbers can be calculated. Depending on the finalization of student theses and publications, data will be submitted to PANGAEA, and will be open for external use.

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## 8.2 Distribution patterns of protest with special emphasis on toxic dinoflagellates in the North Atlantic and Arctic Waters

J. Hessel (AWI), K. Metfies (AWI, not on board)

### Objectives

Climate induced changes in the Arctic such as the drastic decrease in sea ice, ice-thickness or the increase in temperature are expected to impact the biodiversity in pelagic ecosystems. A shift in species composition is expected to occur in all phytoplankton size classes. Within the marine phytoplankton there are toxic micro-algal species (mainly dinoflagellates) known to have the potential to form Harmful Algal Blooms, the so called HABs. Impacts of toxic algae species appear to have increased on a global basis in frequency, intensity and geographic distribution over the past decades (e.g. Zingone and Enevoldsen 2000; Moestrup 2004). Incidences of harmful bloom events in Norwegian waters moved northwards during the past 40 years (Okoldkov 2005). The distribution ranges of HAB-species into or within the Arctic Ocean might further expand northwards due to ongoing temperature increase and larger ice-free regions during summer (Hallegraeff 2010). This might impact Arctic ecosystems due to toxin production, and their accumulation in higher trophic levels. For coastal areas of the Eurasian Arctic there are records of 14 toxic and potentially toxic dinoflagellate species including *Dinophysis sp.* or *Alexandrium sp.* (Okoldkov 2005). However, information on abundance and distributional patterns of these species in the Arctic Ocean is scarce.

We aim to identify current distributional patterns of toxic dinoflagellates in the Norwegian Sea and Arctic Waters in July 2015. In a recent study highest abundances of toxic dinoflagellates were observed during July the North Atlantic (Taylor et al. 2013). Therefore, the timing of the current cruise is well suited to assess the spatial distribution of toxic dinoflagellates in the North Atlantic and Arctic Waters. In addition to surveillance of toxic dinoflagellates, we will characterize the phytoplankton background population in detail in order to elucidate structural community linkages between toxic algae and the surrounding phytoplankton community. The study will be based on collecting samples from surface waters on a regular basis throughout the whole cruise using an automated filtration system and sampling different depths in the water column at the main stations via CTD. Surveillance of the toxic algae and characterization of the background protist community will be based on combination of different molecular genetic approaches focussing on the ribosomal operon, such as Automated Ribosomal Intragenic Sequence Analysis (ARISA), quantitative PCR, an automated rRNA biosensor and next generation sequencing (Illumina).

### Work at sea

We will collect seawater after regular intervals (~ 1° longitude / latitude) starting as soon as possible after RV *Polarstern* has left Bremerhaven. Sampling will be based on using our newly developed **auto**mated **fi**ltration system for **m**arine microbes (AUTOFIM) that is

coupled to the ships pump system. AUTOFIM allows filtration of a sampling volume up to 5 litres. In total 12 filters can be taken and stored in a roundel. Prior to the storage a preservative can be applied to the filters to prevent degradation of the sample material, that can be used for molecular or biochemical analyses. Filtration can be triggered after defined regular time intervals or remote controlled from a scientist at the research institute. Alternatively, filtration could be event-triggered if the filtration system would be operated in connection with the FerryBox System, an *in-situ* measurement device for the monitoring of oceanographic parameter (temperature, salinity, pH etc.) installed on-board *Polarstern*. AUTOFIM provides the technical background for automated high resolution collection of marine samples for molecular analyses. During this cruise we will test AUTOFIM on *Polarstern* for its applicability on board ships. Additionally, we will collect water samples by a CTD/rosette sampler at about 3-4 depths at selected stations in order to evaluate the quality of sampling by AUTOFIM. All samples will be filtered and preserved or frozen at -20°C for further molecular genetic analyses in the home laboratory. We will carry out the following analyses to describe distributional patterns of protist communities and the abundance of toxic microalgae in the observation area:

- Automated Ribosomal Intragenic Sequence Analysis (ARISA) in order to get information on spatial variability of protist communities in the observation area.
- Quantification of toxic algae using an automated rRNA biosensor in order to get information on the abundance of toxic algae in the observation area.
- Quantitative PCR in order to evaluate the data generated with the automated nucleic acid biosensor.
- Next generation sequencing (Illumina) to get information on the protist community structure in selected samples.

### Preliminary (expected) results

Expected Results are information on the spatial distribution of toxic algae and their background protist communities in the North Atlantic and Arctic Waters in July 2015.

### Data management

All molecular genetic data generated from samples collected during the expedition will be stored either in PANGAEA at the AWI, or in public sequence repositories.

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## 8.3 Nitrogen cycling and microbial ecology in the Arctic: Measurements of dinitrogen fixation rates, characterisation of diazotroph assemblages and NIFH gene expression

A. Fong (AWI), S. Spahic (AWI), A. Waite (AWI, not on board)

### Objectives

The process of biological dinitrogen fixation is the conversion of dinitrogen gas to ammonia. Dinitrogen fixation is an energetically expensive process and iron is required in nitrogenase enzyme complex. Additionally, in vitro, the nitrogenase enzyme is sensitive to inactivation by oxygen. Classically, biological dinitrogen fixation is believed to be limited to subtropical and tropical regions of the worlds' oceans, with waters warmer than 25° C and depleted in inorganic nitrogen, such as nitrate. Recent work has shown a greater geographical extent and more diverse *nifH* phylogeny than previously believed, with low, but measureable rates of dinitrogen fixation and recovery of *nifH* genes from polar regions.

Biological nitrogen fixation in aquatic habitats is limited to organisms possessing the *nif* operon. The *nifH* gene is the most common *nif* gene used to identify and quantify the community and expression of nitrogen-fixing organisms. Additionally, dinitrogen fixation rates can be measured by applying a $15N_2$ tracer technique, in which microbial communities are incubated with $15N_2$-enriched seawater.

We plan to use a combination of experiments and techniques to measure dinitrogen fixation rates, characterize the diazotroph community, and measure *nifH* gene expression. Our aim is to broadly sample multiple Arctic environments and link rates of nitrogen fixation to the portion of the microbial assemblages responsible for this process. We will coordinate our efforts with others who are making measurements of ammonia and nitrate uptake rates, so together these rate measurements will provide a comprehensive understanding of nitrogen cycling processes in the Arctic.

### Work at sea

Discrete water column samples from Niskin bottles attached to the main CTD-rosette will be collected. Depths of interest span both the upper ocean and mesopelagic. Incubation experiments with $15N_2$-labeled seawater will be performed to measure dinitrogen fixation rates. Additionally, nucleic acids will be collected by filtration for gene surveys from the same water samples. Small volume water volume samples for flow cytometric and FISH analyses will be collected and archived. Small amounts of material will also be collected from sediment traps for nucleic acids.

At sea-ice stations, ice cores will be collected for the measurement of dinitrogen fixation rates and characterizations of the microbial assemblages. In general, sample collection at sea-ice stations will reflect sampling efforts similar to those for water column measurements.

### Expected results

Sampling is expected to result in measurements of the spatial distributions of nitrogen fixation rates, *nifH* gene expression patterns, and characterizations of microbial assemblages across the study region and within different sampling environments (water column, sea-ice, melt ponds, and surface sediments). A majority of samples will be analysed at the onshore laboratory. Rates, expression patterns, and assemblage composition will be analysed in the context of hydrographic and biogeochemical data.

**Data management**

Most data will be obtained through laboratory analyses after the cruise. Sample processing times are dependent upon parameter and analysis methods. Cruise participants and research partners can obtain data upon request. After publications, data will be submitted to PANGAEA, and will be open for external use.

## 8.4 Vertical export and small mesozooplankton

C. Dybwad (UiT), C. Svensen (UiT), M. Reigstad (UiT, not on board)

**Objectives**

The objective of the work is to quantify the vertical export of biogenic matter under the ice at a vertical gradient ranging from 20 to 200 m depth (Reigstad et al. 2008). As the export is dependent on the available organic material as well as the retention by pelagic consumers, also the small mesozooplankton groups will be identified and quantified. Faecal pellet (FP) production by larger mesozooplankton (i.e. *Calanus* spp.) will be experimentally determined on board. FP production rates will be used as a measure of *Calanus* grazing activity, and by comparing the FP production to the vertical FP export we will obtain an indication of the retention efficiency (Wexels Riser et al. 2008).

Subsamples from the sediment traps will be analysed for pigment composition, and also provide material for collaborative projects involving phytoplankton composition and bacterial characterisation focusing on N cycling.

Vertical export will be related to the quality and quantity of the suspended material in the water column <200 m depth, with respect to particulate organic carbon and nitrogen as well as phytoplankton pigments.

Small mesozooplankton, including copepod nauplii, small copepod taxa and young copepodite stages, is an understudied group of organisms of potentially high importance for C-remineralisation in the euphotic zone (Svensen et al. 2011). Addressing vertical carbon flux, FP production and the small, numerous grazer organisms may increase our knowledge on key pelagic processes.

Additionally, by interpreting results in light of information from cooperating participants on nutrients and productivity, aspects on the fate of carbon from primary production related to the plankton community and vertical export can be addressed (Reigstad et al. 2011).

**Work at sea**

We will sample at the process stations by CTD/rosette (vertical profile 0-200 m, 6-10 depths), sediment traps on mooring, deployed and retrieved from ship anchored to ice floe, WP-2 net. Samples will be filtered or preserved on-board, and stored at -20°C before further analysis.

Suspended material: Subsamples (1.5-2 L) from a vertical water profile for filtration to POC, PON, size fractionated Chl a (tot and >10µm), nutrients (in collaboration with J-E. Tremblay).

Additional water (20L) from Chl a max or upper mixed layer is needed for FP experiments.

WP-2 zooplankton net for collecting *Calanus* for FP experiments

Sediment traps: To be deployed from the ship, and anchored to the ice floe (towing the deployed and neutrally buoyant mooring carefully from the ship to the ice floe using i.e. a rubber boat). Sediment trap cylinders will be deployed at 5-8 depths from 20-200 m for 24 hrs. collection of sinking organic material. Upon retrieval (loosen anchoring, and moving the mooring back to ship for retrieval), material is subsampled and filtered or preserved for analysis of size fractionated Chl a (tot, >10 µm), POC, PON, faecal pellets. Sub-samples for bacterial characterisations and phytoplankton, are taken for collaborative partners. The

mooring will have weight in the lower end (~210 m, and buoyancy at 10, 5 and 0 m). Traps are type KC Denmark double cylinders, without preservatives.

Bottles prepared for primary production incubation (by J-E Tremblay), may be deployed on the sediment trap mooring at predefined depths to measure *in-situ* primary production as nitrate and ammonium uptake.

Small mesozooplankton: 30 L from each of 6 depths will be sampled using the Niskin bottles on the rosette, emptied carefully, and later filtered on 20 µm mesh to collect small species and stages of mesozooplankton. It is important that the volume of each mesozooplankton sample is recorded for each sample.

Faecal pellet experiments is planned to be carried out by sorting out healthy individuals of *Calanus* spp, stage V or females, incubated in water from Chl a max in special FP production chambers. The chambers are kept dark at in situ temperature in cold rooms for 6 hrs. before the copepods and FP material is preserved for later analysis.

**Preliminary (expected) results**

The expected results are a quantification of the vertical carbon export, and the change in export rates with depth and an estimate of the fraction contributed by mesozooplankton faecal pellets. We also have a measure of the stoichiometric composition of the exported material, with ability to indicate terrestrial contributions from ice rafted sediments.

The loss rates of organic carbon, nitrogen and Chl *a* from the water column can be estimated by comparing the suspended and exported material. These data will also be linked to the primary production (PP) measurements measured by J-E. Tremblays group, to quantify the exported faction of PP.

We will also have an estimated measure of the *Calanus* ingestion rate through FP experiments, and the FP retention if individual FP can be adjusted to the *Calanus* abundance data and compared to exported FP rates.

The exported phytoplankton composition and fraction is estimated using size fractionated Chl a, but samples for microscopy analysis, and eventually genetic characterisation will also be taken in collaboration with other partners.

The vertical carbon and pigment flux data, can also provide an estimate of the input to the benthic system by extrapolation.

The small mesozooplankton community will be characterised to evaluate their importance in the Arctic Ocean, their biology and population structure by identifying the different stages of the mesozooplankton species. Their potential impact on the carbon turnover rates can also be evaluated.

By comparing data from the shelf, across the shelf break and into the Arctic Ocean, we will compare the carbon export related to the plankton community and production to identify potential characteristics in the carbon production, fate and export to identify similarities and differences in the ecosystem functioning along the topographic and water mass related gradient.

**Data management**

The data will be analysed at UiT after the cruise, and used for student thesis (PhD and MSci). The data will be interconnected with other partners on board to utilise the synergy of relevant information available. Metadata can be made available after the cruise. A full dataset will be made available after publication in an appropriate database in the PANGEA data base. As students will analyse and publish the data it will take place in a 2-5 year perspective.

**References**

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Reigstad M, Carroll J, Slagstad D, Ellingsen I, Wassmann P (2011) Intra-regional comparison of productivity, carbon flux and ecosystem composition within the northern Barents Sea. Progress in Oceanography, 90, 33-46

Svensen C, Seuthe L, Vasilyeva Y, Pasternak A, Hansen E (2011) Zooplankton distribution across Fram Strait in autumn: Are small copepods and protozooplankton important? Progress in Oceanography, 91, 534-544

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## 8.5 Benthos ecology

M. Kędra (IOPAN), N. Morata (APN/LEMAR), M. McGovern (UiT, APN)

**Objectives**

Climate warming is expected to have the most profound consequences at high latitudes. Since the total and proportional annual primary production of ice algae and phytoplankton will change with shifts in the sea ice extent, thickness and duration, there are likely to be critical consequences for the benthic populations, especially at high latitudes often characterized by tight benthic-pelagic coupling. Recently observed changes in sea ice cover and seawater warming have already been shown to have impacts on the Arctic benthic communities (e.g. Kedra et al. 2010, Grebmeier 2012). However, the potential implications of climate change on the marine ecosystems are not fully understood and especially research at the seasonal sea ice zone is needed. Thus, we propose to evaluate the response of benthic communities to environmental forcing, such as sea ice retreat and seawater warming, as well as potential changes in primary production, in the northern Barents Sea.

The main objective is to investigate how benthic communities structure and function change spatially as a function of environmental conditions and food inputs during the spring bloom, along the sea ice gradient.

**Work at sea**

In order to characterize the inputs of fresh phytodetritus to the seafloor, at each station, 3 replicates sediment cores will be collected and sliced every 0.5 cm until 2 cm, and every 1 cm until 10 cm. Samples will be frozen on board, and analyses of pigments, total organic matter, carbon and nitrogen contents, and granulometry, will be carried out back at the laboratory.

In order to characterize the activities from the overall community (including macrofauna, meiofauna and microfauna), 5 sediment cores will be incubated for 24 to 48h in order to measure respiration and nutrient fluxes of the overall community as indicator of metabolic activities.

The macrofauna community structure will be studied by analysis of taxonomy species identities, total and species abundance, and biomass, function and production. Samples will be collected by box corer; ideally in 4 replicates per station (collected from 2 box-corer casts). Separately, animal tissues of benthic organisms will be taken for the analysis of food web structure based on stable isotopes composition of organic carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$). Animals will be picked up from the remaining sediment, identified on-board and frozen (Hobson and Welch 1992; Iken et al. 2010). To determine food sources the origin of

particulate organic matter (POM) will be assessed with use of $\delta^{13}C$ analyses. 1-2 l of water at the chlorophyll maximum and near bottom will be collected, filtered and filters later frozen (Hobson and Welch 1992).

**Preliminary (expected) results**

We expect that benthic communities' species composition, trophic relations and functioning (including respiration rates), will change along depth and sea ice gradient, but also as a function of food sources.

**Data management**

Data will be published in peer reviewed journals and presented on international conferences. Depending on the finalization of PhD theses and publications, data will be submitted to PANGAEA, and will be open for external use

**References**

Hobson KA, Welch HE (1992) Determination of trophic relationships within a high Arctic marine food web using δ13C and δ 15N analysis. Marine Ecology Progress Series, 84, 9-18.

Grebmeier JM (2012) Shifting patterns of life in the Pacific Arctic and sub-arctic seas. Annual Review of Marine Science, 4, 63-78.

Iken K, Bluhm B, Dunton K (2010) Benthic food-web structure under differing water mass properties in the southern Chukchi Sea. Deep Sea Research II, 57, 71-85.

Kędra M, Włodarska-Kowalczuk M, Węsławski JM (2010) Decadal change in soft-bottom community structure in high arctic fjord (Kongsfjorden, Svalbard), Polar Biology, 33, 1–11.

# 9. TRANSSIZ- GEOLOGY AND PALEOCEANOGRAPHY

M. O'Regan (SU), J. Matthiessen (AWI), A.Kremer (AWI), C. Weng-si (NTU), C. März (NUn), M. Nairn (CUn), C. Stolle (AWI), K. Werner (BPCRC), J. Wollenburg (AWI). Kirsten Fahl (AWI, not on board), M. Forwick (UiT, not on board), K. Hendry (not on board, UBr), C. Lear (CUn, not on board), L. Lowemark (NTU, not on board), J. Müller (AWI, not on board), Rüdiger Stein (AWI, not on board)

**Objectives**

Perennial sea-ice cover is an important and unique component of the global climate system. Reconstructions of sea ice and how it interacted with changing ocean and atmospheric circulation patterns in the past are needed to evaluate modern changes in the Arctic marine system. Sedimentary records collected during previous *Polarstern* expeditions provide key records that underpin our understanding of late Quaternary paleoceanographic conditions in the Eurasian Arctic. However, advances during the past decade(s) in the analytical techniques and climate proxy indicators (proxies) used to reconstruct sea ice and water mass properties from marine sediment archives provide an opportunity to significantly improve these reconstructions. The geology programme on TRANSSIZ is developed to calibrate and test different sedimentary proxies for sea ice and ocean circulation, establish how they are preserved in the sedimentary records, and use the results to improve Arctic paleoceanographic and paleoenvironmental reconstructions during the last one to two glacial cycles.

Of particular interest is the evaluation of the spatial variation in proxies used in Arctic paleoceanography, including how surface ocean and sedimentary signals (co-) vary a) laterally, across the changing ice margin and in the underlying sediments, and b) vertically,

within different water masses that intersect the continental slope. During TRANSSIZ, the Barents Sea shelf to basin transect along 30°E will specifically allow us to assess these changes along the path of inflowing Atlantic Water to the Arctic, and across the marginal ice zone during the late spring /early summer. Besides field investigations on surface sediments and environmental parameters, newly developed high-pressure aquaria will be used to culture surface sediments at *in-situ* pressures under differing temperature and water carbonate chemistry, to establish the first species-specific trace metal calibration curves for the Arctic Ocean. Core top analyses will verify the experimental results.

**Work at sea**

The Geology programme will involve sea ice, water column, pore water and sediment sampling. Sea ice will be sampled using either 9 or 13 cm ice drills. One core at each station will be frozen and analysed on shore to determine the amount of terrigenous and biogenic material, mineralogy, grain size, the second and third core for the elemental and isotopic composition of both the lithogenic fraction and the sea ice (in collaboration with biogeochemistry group), and a fourth core for the composition and abundance of sea ice specific biomarkers.

Water column samples will be collected and processed onboard for shore-based analyses. These include trace metal composition, and carbonate chemistry as well as biomarker analyses for sea ice studies. Plankton tows will be used to characterize the abundance and distribution of foraminifera and Pteropoda in the surface waters, as well as their stable isotope and trace metal ratios

Sediment sampling will involve the collection of one to three multi-cores and 2 gravity cores at each station. Kastenlot cores will be collected at selected sites only (e.g. during the re-occupation of site PS2138). The multi-cores will be divided and used for pore water chemistry, bulk sediment geochemistry, benthic and planktic foraminifera assemblages and the carbon, oxygen and boron isotope ratios and trace metal ratios recorded in their calcareous tests, and for biomarkers (one tube). A minimum of two cores from each multi-core are required for the benthic and foram work at shallower water depths, in the basins three to four cores will be needed to collect sufficient living specimens. At a selected site two multi-corer casts will provide sediments for the culturing of benthic foraminifera at *in-situ* pressure. These newly developed high-pressure aquaria have recently facilitated the first efficient cultivation (producing offspring) of our most trusted palaeo deep-water species *Cibicides wuellerstorfi*. In different experimental set-ups the same facilities will be used to cultivate this foraminifer and associated species at different temperatures and in waters with different carbonate chemistries to establish the first species-specific trace metal calibration curves for the Arctic Ocean. Core top analyses will verify the experimental results.

Gravity and Kastenlot cores will be used to obtain longer sedimentary time series. Pore waters will be extracted immediately from the first of the cores, which will then be logged on the GEOTEK Multi-Sensor Core Logger (MSCL), split and described. This pore-water extracted core will be available for shipboard sampling. The second gravity core will be logged on the MSCL, and will not be split shipboard. The unsplit cores as well as the archive half of the split cores, will be offloaded in Tromsø, Norway at the end of the cruise PS93.1. Whole cores will be imaged on a GEOTEK X-ray imaging system at UiT, and split cores run on the XRF scanning system. The cores will be transferred back to AWI, and the unopened cores will be split and sampled at a later date. When all cores are back at AWI and split, magnetic susceptibility point sensor and colour reflectance measurements will be made with a GEOTEK MSCL-XZ on the archive halves. Analytical methods applied to gravity core pore water and sediment samples will be analogous to the multi-corers.

*In-situ* temperature measurements will be taken when the 2nd gravity core is being collected. These will be done using ANTARES miniature temperature probes, spaced at 0.75 m

intervals on the core barrel. Parasound surveying will be conducted when we first arrive at the Barents Sea slope, and will be used to guide coring site selection.

**Expected results**

By combining the sea ice, water column, pore water and sedimentary analyses, we will be able to assess how surface and bottom water properties are recorded in marine sediments, and to identify the processes that influence their preservation in sedimentary archives from the Arctic. These insights will help refine and advance our interpretations of how sea ice and ocean circulation have evolved across the last one to two glacial cycles, and their connection to changes in sub-Arctic seas. The results from the expedition will not only improve paleoceanographic reconstructions for the Arctic, but will also enhance our ability to interpret records from other regions in the Arctic, and design successful sampling strategies on future expeditions.

**Data management**

Processed data will be submitted to the PANGAEA data repository. Unrestricted availability from PANGAEA will depend on the required time and effort for achievement of individual datasets and its status of scientific publication.

# 10. BATHYMETRIE & PARASOUND

C. Stolle (AWI), J. Matthiessen (AWI), not on board:
B. Dorschel, C. Gebhardt, F. Niessen (all AWI)

**Objectives**

If you are going somewhere and you do not want to get lost – you need a map. Accurate knowledge of the seafloor topography, hence high resolution bathymetry data, is key, basic information necessary to understand many marine processes. It is of particular importance for the interpretation of scientific data in a spatial context. Especially in barely surveyed areas like the ice covered high-latitude ocean, the bathymetry often provides the first view on the seafloor thus providing valuable information on the nature of the seafloor. Bathymetry, hence geo-morphology, is furthermore a basic parameter for the understanding of the general geological setting of an area and many geological processes such as for example erosion, sediment transport and deposition. Even information on tectonic processes can be inferred from the bathymetry. Supplementing the bathymetric data, high resolution sub-bottom data of the top 10s of meters below the seabed provide information on the sediments at the seafloor, the shallow sediment architecture and on the lateral extension of sediment successions. In this way, the sub-bottom data add the 3$^{rd}$ dimension to the bathymetric maps.

Although intensively investigated, areas without high-resolution swath bathymetry coverage still exist on the European Arctic continental shelf and slope. For those areas, the bathymetry is modelled from satellite altimetry with according low resolution. Satellite altimetry derived bathymetry lack the resolution necessary to resolve small- to meso-scale geo-morphological features (e.g. iceberg ploughmarks, sediment waves, and erosional escarpments). Ship-borne multibeam data provide bathymetry information in a resolution sufficient to resolve those features.

On the European Arctic continental shelf and slope, geo-morphological features on the upper continental slopes can provide important information on the maximum advance of ice sheets

across the continental shelves. Furthermore, iceberg ploughmarks can be resolved and identified in swath bathymetry data from these areas. The pathways of icebergs can provide information on prevailing winds and ocean currents in the past, important environmental parameters on the European Arctic continental shelf and slope. Also the abundance of iceberg ploughmarks can be used as a proxy for the amount and sizes of icebergs release into the Arctic Ocean. In addition, the bathymetry is a key data set for the selection of target sites for sediment and rock sampling. In combination with sub-bottom information, these data can be used to optimise the on-site sampling strategy. For example areas of outcropping older strata and areas of reduced or enhanced sediment accumulation can be identified. Furthermore, these data provide information on the adjacent and regional context of the sediment and rock samples.

**Work at sea**

Bathymetric data will be recorded with the hull-mounted multibeam echosound Atlas Hydrosweep DS3 and sub-bottom data will be recorded with the hull-mounted sediment echosounder Atlas Parasound P70. The main task of the bathymetry group is to plan and run bathymetric surveys in the survey areas and during transit. The raw bathymetric data will be corrected for sound velocity changes in the water column and will be further processed and cleaned for erroneous soundings and artefacts. Detailed seabed maps derived from the data will provide information on the general and local topographic setting in the area of the expedition. Simultaneously recorded sub-bottom data provide information on the sedimentary architecture of the surveyed area. High resolution seabed and sub-bottom data recorded during the survey will be made available for site selection and cruise planning. During the survey, the acoustic measurement will be carried out partly supervised.

**Preliminary (expected) results**

Expected results are high resolution seabed maps and sub-bottom information along the cruise track and from the target research sites. The bathymetric and sediment acoustic data will be analysed to provide geomorphological information for the seabed at the northern Barents Sea continental margin. Expected outcomes aim towards a better understanding of the geological and particularly the sedimentological processes in the research area.

**Data management**

Hydro-acoustic data (multibeam and sediment echosounder) collected during the expedition will be stored in the PANGAEA data repository at the AWI. Furthermore, the bathymetric data will be provided to mapping projects and included in regional data compilations such as IBCAO (International Bathymetric Chart of the Arctic Ocean) and GEBCO (General Bathymetric Chart of the Ocean).

# 11. TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

| | Address |
|---|---|
| AWI | Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung<br>Postfach 120161<br>27515 Bremerhaven<br>Germany |
| ABWR | AquaBiota Water Research<br>Löjtnantsgatan 25<br>SE-11550 Stockholm<br>Sweden |
| APN | Akvaplan-niva AS<br>Fram Centre<br>9296 Tromsø<br>Norway |
| BPCRC | Byrd Polar & Climate Research Center<br>1090 Carmack Road<br>The Ohio State University<br>43210-1002 Columbus<br>USA |
| CUn | Cardiff University<br>School of Earth and Ocean Sciences,<br>Main Building, Park Place<br>CF10 3AT, Cardiff<br>United Kingdom |
| DFO | Fisheries and Oceans Canada<br>Freshwater Institute (FWI)<br>501 University Crescent<br>R3T 2N6 Winnipeg<br>Canada |
| DWD | Deutscher Wetterdienst<br>Geschäftsbereich Wettervorhersage<br>Seeschifffahrtsberatung<br>Bernhard Nocht Str. 76<br>20359 Hamburg<br>Germany |
| FMI | Finnish Meteorological Institute,<br>P.O. BOX 503<br>FI-00101 Helsinki<br>Finland |

| | Address |
|---|---|
| GEOMAR | Helmholtz-Zentrum für Ozeanforschung Kiel<br>Wischhofstr. 1-3,<br>24119 Kiel<br>Germany |
| HS-B | Hochschule Bremen<br>Werderstraße 73<br>28199 Bremen<br>Germany |
| IMARES | Institute for Marine Resources & Ecosystem Studies<br>P.O. Box 167<br>1790 AD Den Burg (Texel)<br>Niederlande |
| IOPAN | Institute of Oceanology<br>Polish Academy of Sciences<br>Powstańców Warszawy 55<br>81-712 Sopot<br>Poland |
| LEMAR | Laboratoire des sciences de l'Environnement MARin<br>20 avenue Le Gorgeu<br>29200 Brest<br>France |
| LSCE | Laboratoire des Sciences du Climat et de l'Environnement,<br>Unité mixte CEA-CNRS-UVSQ<br>CE Saclay Orme des Merisiers<br>F-91191, Gif-Sur-Yvette<br>France |
| NTU | National Taiwan University<br>Department of Geosciences<br>No 1. Sec. 4 Roosevelt Road P.O. Box 13-318<br>Da'an District, Taipei City<br>Taiwan 10617 |
| NPI | Norwegian Polar Institute<br>Fram Centre, P.O. BOX 6606 Langnes<br>N-9296 Tromsø<br>Norway |
| NUn | Newcastle University<br>School for Civil Engineering and Geosciences (CEG)<br>NE1 7RU<br>Newcastle upon Tyne<br>United Kingdom |

| | Address |
|---|---|
| PML | Plymouth Marine Laboratory<br>Prospect Place<br>The Hoe<br>Plymouth, PL1 3DH<br>United Kingdom |
| SUn | Stockholm University<br>Department of Geological Sciences<br>Svante Arrhenius väg 8<br>SE-106 91, Stockholm<br>Sweden |
| UBr | University of Bristol,<br>Senate House,<br>Tyndall Avenue,<br>Bristol, BS8 1TH<br>United Kingdom |
| UH | University of Helsinki<br>Yliopistonkatu 4<br>00100 Helsinki<br>Finnland |
| UHB | University Bremen<br>Bibliothekstraße 1<br>28359 Bremen<br>Germany |
| UHH | University of Hamburg<br>Martin-Luther-King Platz 3<br>20146 Hamburg<br>Germany |
| UiT | University of Tromsø<br>Hansine Hansens veg 18<br>9019 Tromsø<br>Norwegen |
| UnS | Université de Sherbrooke,<br>Faculté des lettres et Sciences Humaines<br>Département de Géomatique<br>2500 Boulevard de l'Université<br>Sherbrooke QC J1K 2R1<br>Canada |
| UTR | Universität Trier<br>Universitätsring 15<br>D-54286 Trier<br>Germany |

| | Address |
|---|---|
| Takuvik/UnL | Takuvik Joint International<br>Laboratory, Université Laval (Canada) - CNRS (France)<br>Département de Biologie and Québec-Océan<br>Pavillon Alexandre Vachon<br>1045, Avenue de la Médecine<br>Université Laval<br>Québec QC G1V 0A6<br>Canada |
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# 12 . FAHRTTEILNEHMER / CRUISE PARTICIPANTS

| Name/ Last name | Vorname/ First name | Institut/ Institute | Beruf/ Profession |
|---|---|---|---|
| Peeken | Ilka | AWI | Chief scientist, Sea ice ecology |
| Blais | Marie-Amélie | Takuvik/UnL | Student, Green-Edge |
| Brauer | Jens | HeliService | Pilot |
| Bruyant | Flavienne | Takuvik/UnL | Group leader, Green-Edge |
| Büttner | Stefan | GEOMAR | Student, Biogeochemistry |
| Castellani | Giulia | AWI | Scientist, Under Ice & zoolankton ecology |
| Cochrane | Paul | AWI | Scientist, Sea ice physics |
| Dietrich | Ulrike | UHB | Student, Sea ice ecology |
| Dybwad | Christine | UiT | Student, Plankton ecology |
| Findlay | Helen | PML | Scientist, Trace Gases |
| Flores | Hauke | AWI | Group leader, Under Ice & zooplankton ecology |
| Fong | Allison | AWI | Group leader, Plankton ecology |
| Fradette | Maxime | UnS | Student, Green-Edge |
| Gros | Valérie | LSCE | Group leader, Trace Gases |
| Heim | Thomas | HeliService | Mechanic |
| Hessel | Johanna | AWI | Student, Plankton ecology |
| Hölemann | Jens | AWI | Scientist, Oceanography |
| Janout | Markus | AWI | Scientist, Oceanography |
| Juhls | Bennet | GEOMAR | Scientist, Oceanography |
| Katlein | Christian | AWI | Student, Sea ice physics |
| Kedra | Monika | IOPAN | Group leader, Benthos ecology |
| Korhonen | Meri | FMI/UH | Scientist, Oceanography |
| Krumpen | Thomas | AWI | Group leader, Sea ice physics |
| März | Christian | NUn | Scientist, Geology |
| Matthießen | Jens | AWI | Scientist, Geology |
| McGovern | Maeve | APN | Student, Benthos ecology |
| Meisterhans | Guillaume | DFO | Scientist, Sea ice ecology |
| Meler | Justyna | IOPAN | Technician, Biogeochemistry |
| Miller | Max | DWD | Meteorologist |
| Morata | Nathalie | APN | Scientist, Benthos ecology |
| Müller | Juliane | AWI | Scientist, Geology |
| Nairn | Michael | CUn | Student, Geology |
| Nikolopoulos | Anna | ABWR | Group leader, Oceanography |
| O'Regan | Matt | SUn | Group leader, Geology |
| Park | Eunmi | AWI | Student, Biogeochemistry |
| Randelhoff | Achim | NPI/UiT | Student, Oceanography |
| Richter | Roland | HeliService | Inspector |
| Sarda-Esteve | Roland | LSCE | Engineer, Trace Gases |
| Schaafsma | Fokje | IMARES | Student, Under Ice & zooplankton ecology |
| Schulte-Kortnack | Sebastin | HB | Scientist, Sea ice physics |
| Sonnabend | Hartmut | DWD | Meteorology |
| Spahics | Susanne | AWI | Technician, Plankton ecology |

| Name/ Last name | Vorname/ First name | Institut/ Institute | Beruf/ Profession |
|---|---|---|---|
| Stolle | Clara | AWI | Student, Geology |
| Svensen | Camilla | UiT | Scientist, Plankton ecology |
| Tonkes | Henrieke | AWI | Student, Under Ice & zooplankton ecology |
| Ungermann | Mischa | AWI | Student, Sea ice ecology |
| van Dorssen | Michiel | v.D. Met. | Technician, Under Ice & zooplankton ecology |
| Vaupel | Lars | HeliService | Pilot |
| Vortkamp | Martina | AWI | Technician, Under Ice & zooplankton ecology |
| Weng-si | Chao | NTU | Student, Geology |
| Werner | Kirstin | BPCRC | Scientist, Geology |
| Willmes | Sascha | UTR | Scientist, Sea ice physics |
| Wollenburg | Jutta | AWI | Scientist, Geology |
| Zabłocka | Monika | IOPAN | Group leader, Biogeochemistry |

# 13. SCHIFFSBESATZUNG / SHIP'S CREW

| No. | Name | Rank |
|---|---|---|
| 01. | Wunderlich, Thomas | Master |
| 02. | Lauber, Felix | 1.Offc. |
| 03. | Westphal, Henning | Ch.Eng. |
| 04. | Kentges, Felix | 2.Offc. |
| 05. | Stolze, Henrik | 2.Offc. |
| 06. | Fallei, Holger | 2.Offc. |
| 07. | Spilok, Norbert | Doctor |
| 08. | Hofmann, Jörg | Comm.Offc. |
| 09. | Schnürch, Helmut | 2.Eng. |
| 10. | NN | 2.Eng. |
| 11. | Rusch, Torben | 2.Eng. |
| 12. | Brehme, Andreas | Elec.Tech. |
| 13. | Ganter, Armin | Electron. |
| 14. | Dimmler, Werner | Electron. |
| 15. | Winter, Andreas | Electron. |
| 16. | Feiertag, Thomas | Electron. |
| 17. | Schröter, Rene | Boatsw. |
| 18. | Neisner,Winfried | Carpenter |
| 19. | Clasen, Nils | A.B. |
| 20. | Burzan, Gerd-Ekkehard | A.B. |
| 21. | Schröder, Norbert | A.B. |
| 22. | Leisner, Bert | A.B. |
| 23. | Hartwig-L., Andreas | A.B. |
| 24. | Kretzschmar, Uwe | A.B. |
| 25. | Müller, Steffen | A.B. |
| 26. | Gladow, Lothar | A.B. |
| 27. | Sedlak, Andreas | A.B. |
| 28. | Beth, Detlef | Storekeep. |
| 29. | Plehn, Markus | Mot-man |
| 30. | Klein, Gert | Mot-man |
| 31. | Krösche, Eckard | Mot-man |
| 32. | Dinse, Horst | Mot-man |
| 33 | Watzel, Bernhard | Mot-man |
| 34. | Meißner, Jörg | Cook |
| 35. | Tupy,Mario | Cooksmate |
| 36. | Völske, Thomas | Cooksmate |
| 37. | Luoto, Eija | 1.Stwd. |
| 38. | Schwitzky-S., Carmen | Stwdss/KS |
| 39. | Mack, Ulrich | 2.Steward |
| 40. | Hischke, Peggy | 2.Stwdess |
| 41. | Wartenberg, Irina | 2.Stwdess |
| 42. | Hu, Guo Yong | 2.Steward |
| 43 | Chen, Quan Lun | 2.Steward |

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